CAROL BRESLIN

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NATURAL HISTORY

VOLUME 88, 1979

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JANUARY NO. 1

FEBRUARY NO. 2

MARCH NO. 3

APRIL NO. 4

MAY NO. 5

JUNE–JULY NO. 6

AUGUST–SEPTEMBER NO. 7

OCTOBER NO. 8

NOVEMBER NO. 9

DECEMBER NO. 10

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AUTHORS AND TITLES

SUBJECT MATTER

NATURAL HISTORY

JANUARY 1979 • $1.25

RABBIT THE #1 SELLING CAR IN SWITZERLAND.

The Swiss are no cuckoos.

They sit surrounded by Germany, Italy and France – all of the biggest car makers in Europe.

Their choice of cars is unlimited. Yet the car they buy most is the Volkswagen Rabbit.

It seems fair to ask why.

To begin with, mountain climbing isn't just a hobby in Switzerland; it's the way everyone drives. Good weather or bad (especially bad) there is nothing like Rabbit's front-wheel drive to get a car up an Alp. Or a Rocky, or even a steep driveway.

Also, the Swiss worship precision; it's what makes them tick. Car and Driver described the Rabbit this way: "Quality is exceptionally high throughout, with solid slamming doors and a structure that feels as substantial as a Mosler safe."

The Swiss also dote on technology. Fuel injection, for example.

You might be as interested as the Swiss to know that you can't get a Renault with fuel injection. Or a Fiat. Or a Lancia. Not to mention Toyota, Honda, or Mazda. But you can get a fuel-injected Rabbit.

Last, but hardly least, is the fact that the Swiss are – well – frugal. And so when they see a car that's built like a vault, climbs like a goat, is far ahead of its time and still sells for a reasonable price, the Swiss do what sensible people everywhere do.

They buy them in droves.

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NATURAL HISTORY

Incorporating Nature Magazine
Vol. 88, No. 1
January 1979

American Museum of Natural History
Robert G. Goelet, President
Thomas D. Nicholson, Director

Cover: *Children watch a festival in Katmandu, Nepal, through an elaborately carved window frame. The architecture—and other human customs—of some mountain communities in Nepal and Switzerland are surprisingly similar. Photograph by Malcolm S. Kirk, Peter Arnold Photo Archives.* *Story on page 32.*

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Authors

Dorothy Eber is a Canadian journalist whose special interest is documentary reportage. She is at present collecting oral histories from the graphic artists of Cape Dorset. When the Eskimo she interviewed spoke of Robert Flaherty, who took pictures in the area in 1913, Eber wondered what had become of the photographs. Chance later brought her into contact with Monica Flaherty, who gave her the opportunity to see her father's photographs and take them to Cape Dorset for identification. Eber's published oral histories include *People From Our Side* and *Pitseolak: Pictures Out of My Life*. A previous contributor to *Natural History*, Eber received her B.A. from the University of Toronto.

During his investigations of living crinoids, **David L. Meyer** has made more than 800 scuba dives in the Caribbean Sea and the Pacific Ocean. Invertebrate paleobiology is his specialty, and in following it, he has found that both diving and underwater photography have become avocations for him as well as research tools. Meyer did his undergraduate work at the University of Michigan and took his Ph.D. in geology at Yale University. He has worked at the Smithsonian Tropical Research Institute in the Canal Zone in Panama and is now assistant professor of geology at the University of Cincinnati.

Interested in paleontology and marine biology, coauthor **D. Bradford Macurda, Jr.**, began collecting fossil crinoids in the 1960s. At present a research specialist with the Exxon Production Research Company in Houston, Texas, Macurda formerly taught geology and mineralogy at the University of Michigan. He has explored fossil crinoids in the United States, Europe, Asia, Africa, and Australia, and living crinoids in the Indian, Pacific, and Atlantic oceans. Macurda has a Ph.D. in geology from the University of Wisconsin.

"In 1962," writes **Robert E. Rhoades,** "I joined the Peace Corps and was sent to Nepal. As I was a farmer from the flatlands of Oklahoma, you can imagine my reaction to a vertical terrain. Everything was different. Of all the foreigners then assisting Nepal, the Swiss were the most effective and respected. They had a second sense about the mountains, which I came to understand a decade later while conducting research in the Alps. During a night spent in a Swiss alpine hut similar to ones that had sheltered me in Nepal, I formulated the ideas expressed in my article." Rhoades is an anthropologist at the University of Arizona in Tucson.

On Photographing a Monster

It *hates* being photographed. It glares balefully at the camera. It sulks, fidgets, pouts.

It is that most fearsome of creatures, a perfectly normal four-year-old child.

The photographer, wise in the ways of distracting difficult subjects, abandons his camera. He wanders about the studio, talking and gesturing. The monster, no longer feeling threatened by the evil eye of the lens, relaxes and becomes once more the sweet child its mother knows.

From time to time, the eye of the camera blinks. There is a quiet whirring of an electric motor, and the camera blinks again. Yet the photographer is nowhere near it.

An Ingenious Little Dial.

The camera is a Hasselblad, the motor-drive 500EL/M.

A dial on the camera is set at "SR." This prereleases the entire reflex system. At the end of a 20-foot extension cord, the photographer holds a release mechanism. When triggered, it operates the leaf shutter without a moment's delay, thus reducing the risk of "eye blink" from the subject and delivering a higher number of useable photographs.

There are four other settings on this dial: Single-frame in the normal mode. Continuous, automatic firing for as long as the release is held down. A single frame in the prereleased, speeded-up mode for one frame only. And continuous, automatic firing in the speeded-up mode at the rate of one frame every 8/10th of a second.

Hasselblad Versus 35mm.

Why is this photographer not using one of the many excellent motor-drive 35's for this assignment?

One compelling reason might be the size of the Hasselblad negative. Each is 2¼ inches square, *almost four times the area of a 35mm frame.* (See box, below right, for actual size.)

To make an 11 x 14 print of the child, one would have to enlarge a 35mm negative 11.6 times. A comparable Hasselblad print requires only a 7-times enlargement. The ability to hold contrast is phenomenal.

Then there is the camera's leaf shutter. Unlike the shutter of a 35mm camera, it is fully synchronized for every type of flash at every speed up to 1/500th of a second.

Hasselblad Versus Others.

But why a Hasselblad when there are less-expensive alternatives? Why did eight out of ten top professional photographers surveyed name Hasselblad as the medium-format camera used in their work?

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A lavish brochure on the 500EL/M and other Hasselblad cameras is available free if you write: Braun North America, Dept. NHIH, 55 Cambridge Parkway, Cambridge, Mass. 02142—a division of The Gillette Company and exclusive marketer of Hasselblad in the U.S.

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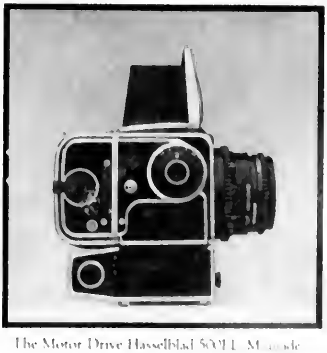

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A wildlife research biologist with the U.S. Fish and Wildlife Service, **L. David Mech** is a leading authority on wolves. He has studied this maligned predator in Minnesota; Alaska; Isle Royale, Michigan; and Italy. Using radio collars, tracking antennas, and airplanes, he has plotted the movements of wolves and unraveled some of the mystery surrounding them. Working mainly in Superior National Forest, Mech has concentrated on the social biology of wolves and deer, wolf–deer interactions, wolf population trends, and the hormonal aspects of wolf behavior. He has written many articles for *Natural History;* the last, "A New Profile for the Wolf," appeared in April 1974.

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John Solomon Otto became interested in the archeology of slave cabins and plantations while a graduate student at the University of Florida. He worked with well-known archeologist Charles Fairbanks at the Cannon's Point excavation described in this issue and, since then, has done fieldwork in eastern Tennessee and western Arkansas. For a year, Otto was a staff archeologist for the National Park Service; he is now an assistant professor of anthropology at Brown University, Providence, R.I. "Currently," he writes, "I am studying the history of slavery in a western Arkansas community by collecting oral traditions from the descendants of slaves and slaveholders and by researching county tax records and federal census records."

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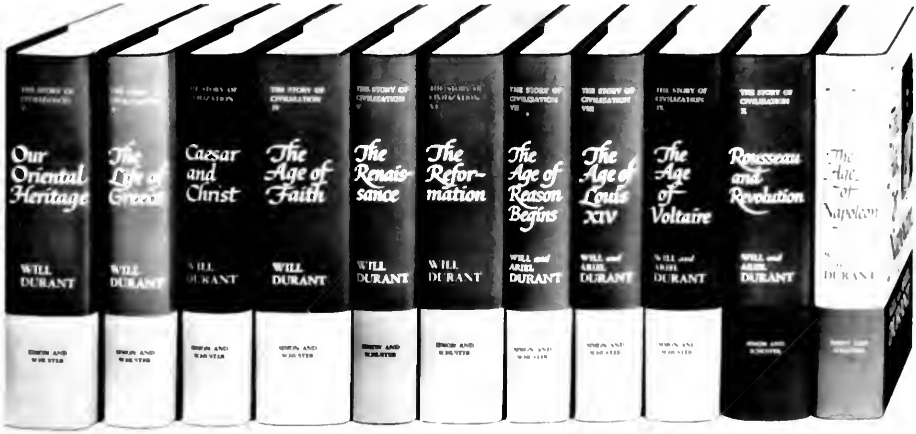

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Margaret Mead

1901–1978

Irene Kubota

From the window of the small hospital room in New York, where Margaret Mead died peacefully on the morning of November 15, the East River glistened in the autumn sunlight as it flowed out to sea. The family pictures on the wall and the walking stick in the corner showed that the room had been home for her last six weeks of life.

Margaret Mead never had a typical home. Yet she was never without one. In her early life her parents moved at least four times a year to teach and study. In each new home Margaret would quickly claim her room, usually at the top of the house, private and secure.

When she came to the American Museum of Natural History in 1926 as an assistant curator, she found a small temporary office in the top of the west tower, and it became her permanent home for the rest of her life.

Against the advice of many, she went to the South Seas as a young woman to do anthropological fieldwork. She returned there many times.

Margaret's life was as restless as any ocean. She traveled constantly, making new friends and revisiting old ones. Her only consistent haven was in her office, and possibly a few villages in the Pacific, such as Pere.

In coming years, biographers will illuminate the many facets of Margaret Mead: scholar, scientist, cultural anthropologist, commentator, humanist, champion of the young and old, the oppressed and misunderstood. But the biographers might miss two facets that explain much of her phenomenal impact on so many people in the world.

First, she was a deeply religious woman. Her sense of good and bad was astute and ever present. She always strove to do good.

Secondly, she had a touch of the poet. Not in the sense of a precise polisher of words, but in the broader sense of finding the right image or metaphor that would have an awesome truth. She had an intuitive sense of timing. Her insights, sometimes based on only fragments of information, most often proved correct.

She did not spare herself from her own insights. A year ago, with a note of betrayal in her voice, she said, "My body isn't going to last as long as I thought it would."

In mid-September at the Museum's five-day film festival in her honor, the will and mind again dominated. She sparkled in discussions on stage. But at night the pain of cancer returned. She entered the hospital on October 4.

As Margaret Mead often noted, the villagers of Pere have much to teach us. When she left the village, they would beat the death drums and mourn. She was, they said, like an old turtle going to sea for the last time. Much to their joy, she returned four times, each time a little wiser, a little slower, a little more turtlelike.

The old turtle has gone to sea for the last time. The villagers of Pere, who understand about turtles, and death, and the sea, need only nod. But we, who suddenly sense a deep hole in our lives, must deal with a painful sorrow.—A.P.T.

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A New Look at Slave Life

by John Solomon Otto

Excavation of slave cabin ruins in Georgia turns up the unwritten legacy of millions of American blacks

Our understanding of the daily life of slaves on plantations in the Old South was, until quite recently, based upon a few somewhat unreliable written sources. Much of what we knew came from the writings of white planters and white visitors to plantations, but these elite observers saw only a few aspects of the slaves' lives. Another source has been a group of autobiographies of former slaves. Some were written by blacks, others were dictated by blacks to white editors, and many were published in the antebellum North as antislavery propaganda. The authors were usually young men, craftsmen, or border state ex-slaves. Since few women, field hands, and slaves from the Deep South left autobiographies, these narratives probably are not typical of the lives of all slaves throughout the Old South.

Former slaves also contributed to the record about slavery through autobiographies written after the Civil War. During the 1920s black scholars, from Fisk and other southern universities, and in the 1930s Works Progress Administration interviewers talked to hundreds of former slaves about life in the South both before and after Appomattox. The narrators in the WPA project included men and women who had lived in the Old South, but their reminiscences were often marred by lapses of memory, colored by postbellum experiences, or misinterpreted by white interviewers. All these

Continued on page 16

Photographs courtesy of Hampton Institute Archives

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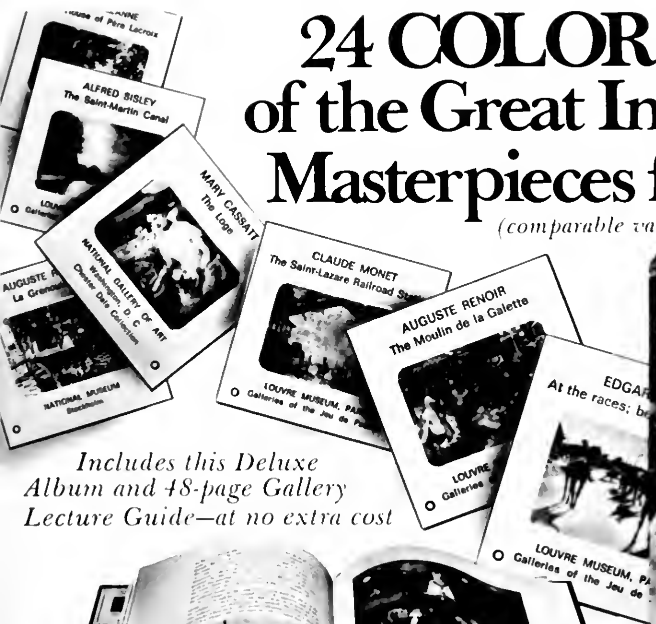

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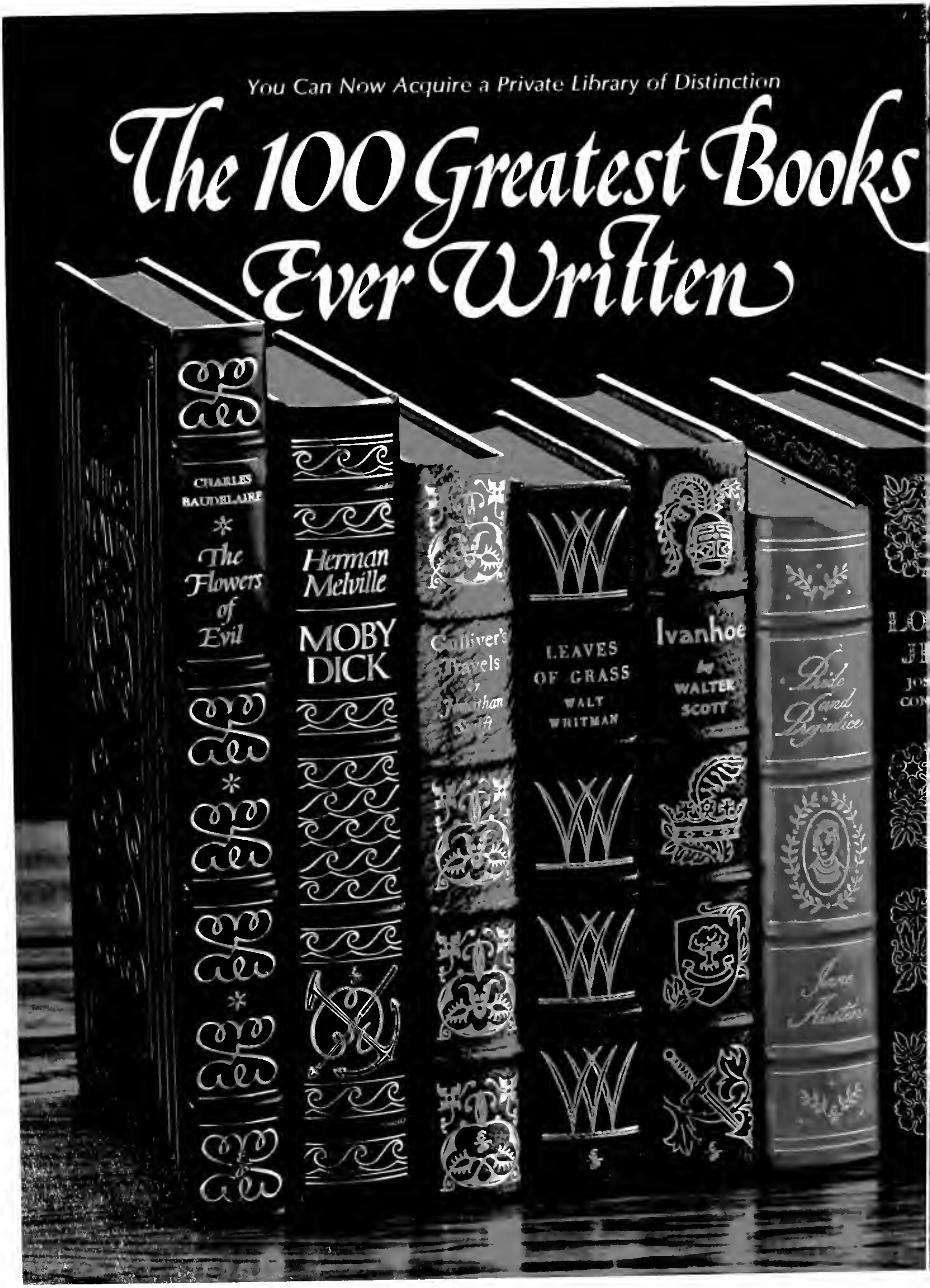
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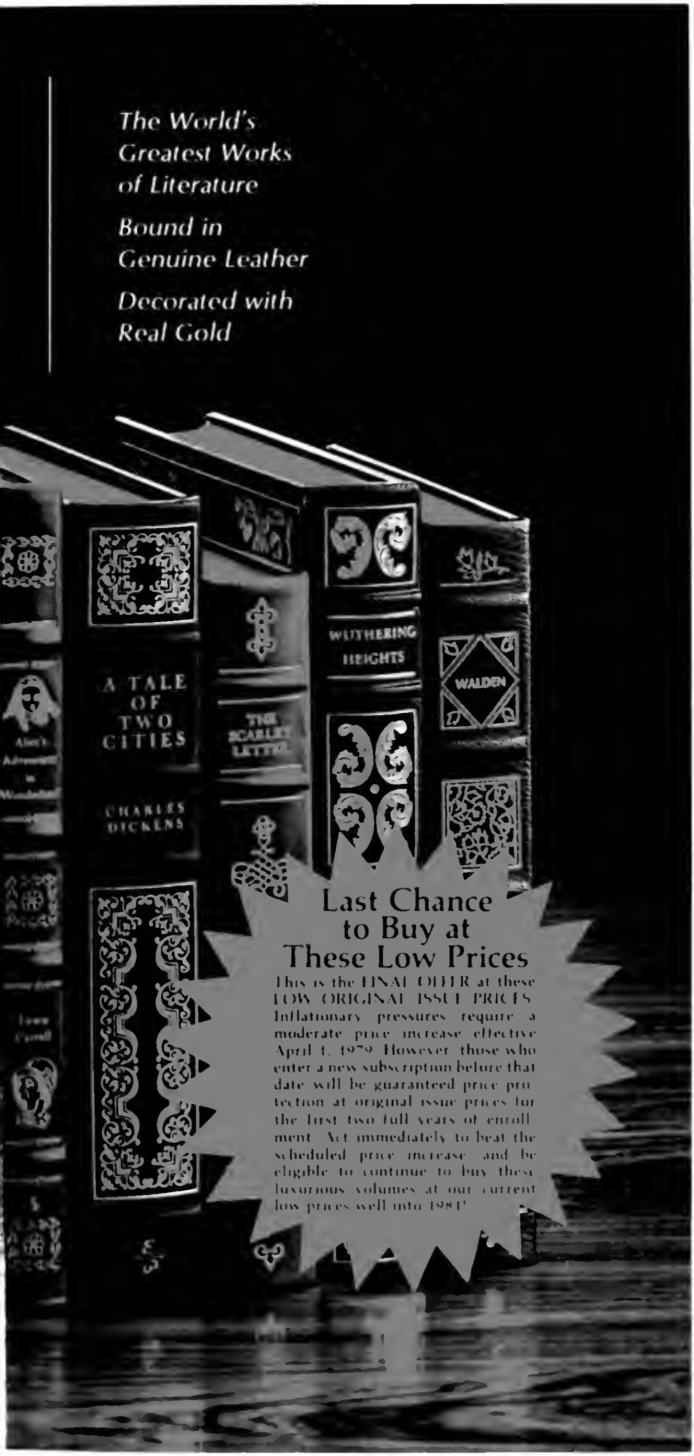

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written sources suffer the risk of being incomplete or biased. Many are unrepresentative, since just a handful of slaves in the South were able to leave any written legacy at all.

Only in the past decade have scholars begun to use another type of source to study how Old South slaves lived. Led by Charles Fairbanks of the University of Florida, some historical archeologists have made a close examination of the unwritten legacy of millions of slaves—the abandoned cabins, discarded artifacts, and food remains found on old cotton plantations. In 1968, Fairbanks began excavating the ruins of slave cabins on Kingsley Plantation, Fort George Island, Florida. The next year, he and Robert Ascher, an anthropologist at Cornell University, excavated a slave cabin on Rayfield Plantation, Cumberland Island, Georgia. And in 1973, Fairbanks began excavations at Cannon's Point, on Saint Simon's Island, Georgia, about halfway between Jacksonville, Florida, and Savannah, Georgia. I worked with Fairbanks at the Cannon's Point excavation.

The goal of excavating slave cabins—as with most archeological digs—is to recover tangible evidence of the housing, possessions, food, crafts, recreation, and general life style of long-dead former residents. Unlike many written sources, which are often directed toward posterity, archeological remains are neither biased nor falsified. When they discarded broken cups or bones 150 years ago, slaves had no idea that the objects would eventually interest archeologists.

Archeological evidence does have limitations, however, as not all materials survive over time. Clothing, wood, and plants often decay, whereas iron, ceramics, and bones usually survive. But by combining the incomplete archeological record with the incomplete written record, fieldworkers have been able to achieve a clearer appreciation of how slaves lived. Comparison of written and archeological sources also permits an evaluation of the accuracy of slave narratives and reports by plantation owners and white visitors.

Cannon's Point—the most recent site of the slave cabin excavations—was from 1793 to 1861 a Sea Island cotton plantation owned by John Couper and his son James Hamilton Couper. The site contains the ruins of two sets of four slave cabins and their middens. At one of these cabins, we were able to expose the foundations and chimney and much of the midden, which contained nonperishable possessions and food remains discarded by two generations of slaves. The possessions include objects used for daily work and household chores, for gathering and growing food, and for recreation. Among the food remains are bones of both domestic and wild animals.

We were able to evaluate these remains alongside various surviving written sources available from Cannon's Point and from other Sea Island plantations. Among these documents are plantation accounts,

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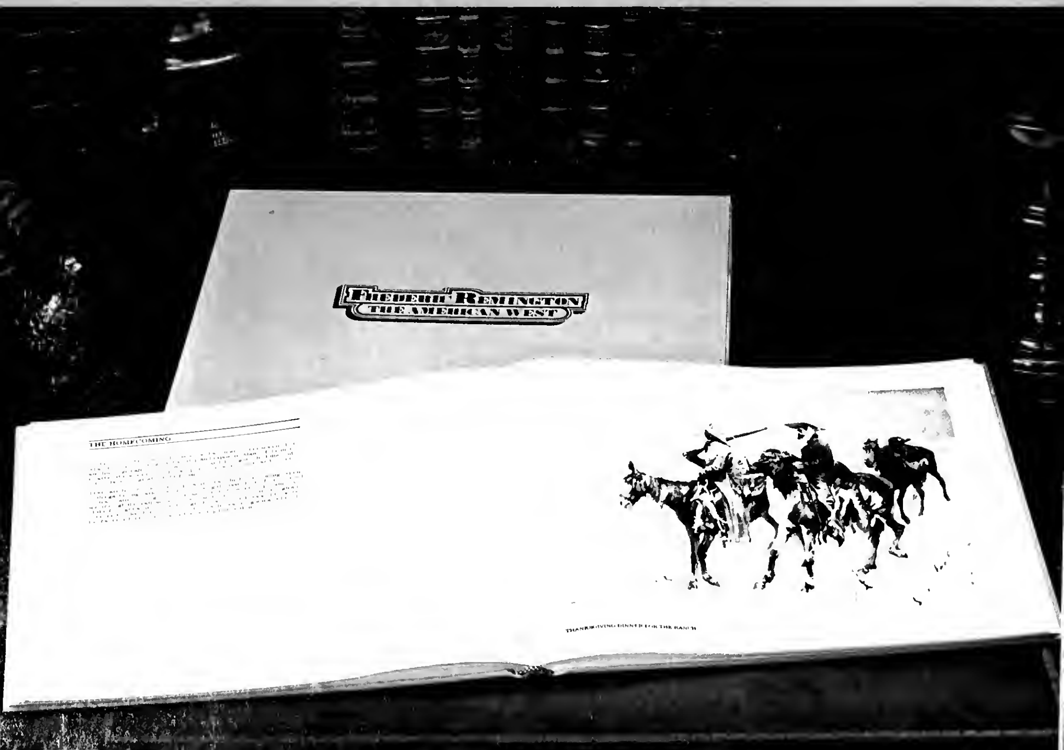

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letters written by the planter and his family, and descriptions of the plantation left by such visitors as Aaron Burr, Basil Hall, Fanny Kemble, and Sir Charles Lyell.

One of the things we discovered was the work schedule for the Cannon's Point slaves. The majority of the hundred or so slaves on the plantation cultivated such cash and food crops as Sea Island cotton, corn, cowpeas (now called black-eyed peas), and sweet potatoes. Each day during the growing season, overseers and foremen assigned work to the field slaves in the morning and inspected the finished work. Basil Hall, who visited Cannon's Point in 1828, noted that some slaves, called full hands, cultivated one-half to three-quarters of an acre daily using iron broad-hoes. Other slaves, among them the young, the elderly, and the ill, were partial hands, who performed less work. Hall claimed that most Cannon's Point slaves finished their tasks by "midday" and devoted the remainder of the day to "fishing and dancing." Archeological evidence shows this to be an exaggeration. Slaves spent their hours away from the field doing household chores, making handicrafts, hunting and fishing, cultivating their own food, and entertaining themselves with dancing.

Fishing was seriously pursued since fish were an important part of the slaves' diet. The refuse contains a lead slip-sinker used in hook-and-line fishing. With this equipment, the slaves could have caught most estuarine fish except for mullet, which they might have trapped with nets in tidal streams. The slaves apparently stayed close to shore, rarely venturing out into the sounds and landward marshes that surround Saint Simon's Island. They caught stingray, sturgeon, gar, perch, sea trout, kingfish, croakers, drum, mullet, and flounder, as well as diamondback and soft-shelled terrapin.

We were surprised to find indications that the slaves owned firearms. Lead shot, a gunflint, and a percussion cap all lay in the midden. Such evidence of slave-owned firearms—admittedly indirect—has also appeared at other slave cabin sites excavated on the Georgia and Florida coasts, and we know that the state of Georgia never enacted any laws prohibiting slave ownership of firearms. Using either firearms or traps, Cannon's Point slaves collected opossums, rabbits, wood rats, raccoons, minks, and clapper rails; remains of each appear in the midden.

The slaves caught fish, mammals, and wildfowl to supplement and vary the weekly rations, primarily vegetables, that they received from the Couper family. According to Hall's account, in 1828 each adult slave received either nine quarts of corn, a bushel of sweet potatoes, or two pecks of unhusked rice known as paddy. Each child received between five and eight quarts of corn. Nineteenth-century dietary knowledge apparently led the planter to believe that corn was more nutritious

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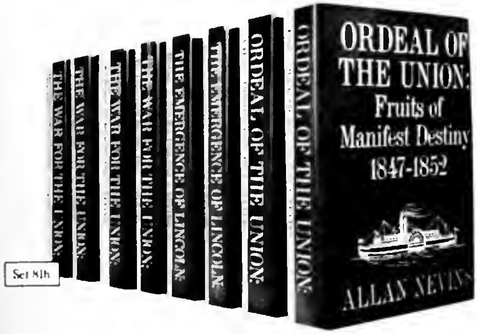

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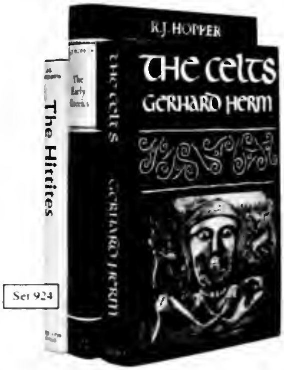

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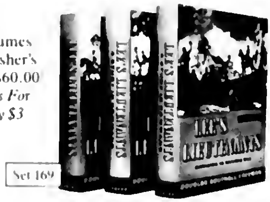

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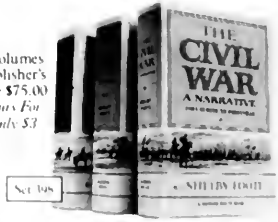

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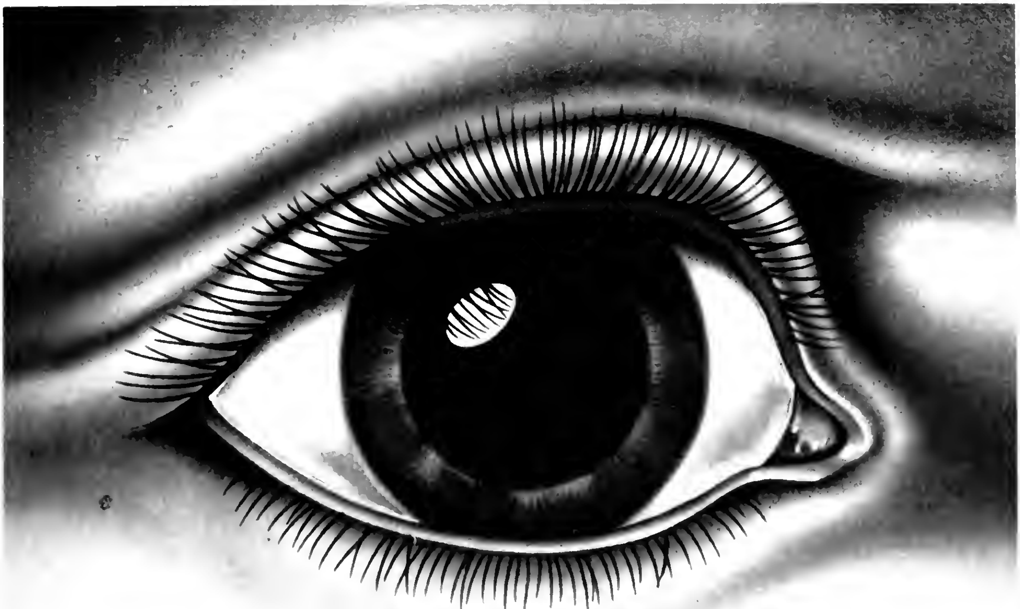
than sweet potatoes or brown rice. Plantation accounts also record bulk purchases of rice flour, "second quality" and "small" rice, and molasses for issue to slaves. In addition, a special patch of cabbage and cauliflower was cultivated for the slaves, who were also given their pick of the cabbage and rutabaga from the fodder crop.

Sam Hilliard, an authority on southern foodways, has written that Old South planters usually issued each adult slave a peck (eight quarts) of corn and two to five pounds of bacon every week. Thus the Cannon's Point slaves received a larger than average ration of corn, but according to plantation records, they were rarely issued meat. Hall reported that slaves were issued no bacon but were given some salt fish and, occasionally, salt beef. The presence of food bones in the slave refuse suggests that although the slaves may have received sporadic rations of fresh meat from cattle, sheep, and hogs when the planter butchered his lifestock, they probably supplied much of their protein by hunting, fishing, or keeping domestic animals.

The Cannon's Point slaves fed their hogs and poultry with surplus corn from their own rations. Their hogs, marked or branded, might have been penned, tethered, or allowed to range through the live oak hammocks of the plantation, visiting slave cabins for food. The slaves probably butchered and ate most of the hogs, but some of the animals may have been sold to the planter family or to local merchants. Rabbits as well as domestic fowl and their eggs provided the slaves with another source of food and income. The Cannon's Point slaves also cultivated plots of one or two acres for their own food, planting the same crops that they received as rations.

The refuse indicates that the slaves had few cooking utensils; only fragments of cast-iron pots are present. This suggests that meals consisted of meats, grains, and vegetables combined in one pot. Corn, the primary foodstuff, might have been cooked as hominy, cornmeal mush, or pottage, and any available meat was probably added. Cracked second quality and small rice could have been cooked as pilau, or perlou, still eaten in tidewater Georgia and consisting of boiled rice, salt meat, fish, game, and vegetables. Another popular dish was "Hopping John," in which cowpeas were mixed with rice and salt meat.

A former slave, Charles Ball, described such one-pot meals in his autobiography, *Fifty Years in*



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Chains, written in 1859: "The whole [stew] had been boiled . . . until the flesh had disappeared from the bones, which were broken in small pieces—a flitch of bacon, some green corn, squashes, tomatoes, and onions had been added. . . ."

We saw no saw marks on the broken mammal bones we found in the slave cabin refuse, which suggests that the meat was not divided up into regular cuts and joints for roasting. The ax and knife marks we did find are evidence that slaves stripped meat off the bones, which they then broke and threw into the stew pot along with the meat and vegetables. The resultant stew was eaten out of hemispherical bowls, and the liquid was sopped up with bread made from cornmeal and rice flour and baked in hearth ashes or on a hoe.

The refuse indicates that the slaves were issued ceramic tableware, such as bowls, plates, storage jugs, jars, teacups, saucers, and platters. They also may have received chamber pots—a relative luxury. "There are seldom or never any conveniences in the way of chambers," J. Hume Simons wrote in a widely read antebellum medical tract, *The Planter's Guide and Family Book of Medicine*, published in 1849. Simons urged that planters provide a "seat with a hole and cover for the calls of nature" in each slave cabin.

Cannon's Point slaves who became ill were given "plantation medicines," such as castor oil, spirits of turpentine, blue mass, quinine, laudanum, paregoric, and epsom salts. The planter's wife or the overseer made the diagnosis and distributed these medicines in bottles and vials whose fragments we found in the refuse. According to early nineteenth-century medical theory, these bromides were meant to restore the balance of "bodily humours" and purge the slaves' bodies of "morbific matter."

Adult slaves were issued some clothing, as well as cloth, thread, needles, and buttons with which the women could make additional clothing. In 1828, for winter wear each male slave received seven yards of white Welsh plain (a kind of flannel), each woman six yards, and each child somewhat less. For summer wear, the slaves were issued osnaburg, a type of coarse, durable cotton. Many buttons issued to the slaves turned up in the cabin refuse—including a brass U.S. Navy button that probably came from a surplus military coat given to a slave. Besides the remains of objects issued by the planter, the ruins include certain luxury items that the slaves must have purchased. A visitor to Cannon's Point claimed that the slaves laid out their incomes on "dress and trinkets," but there is archeological evidence that they also purchased liquor, tobacco, and firearms from local merchants, using money from the sale of produce and handicrafts.

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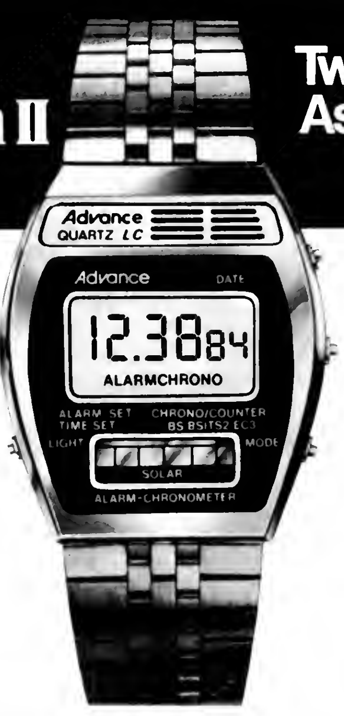

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In his brief career, spanning only 10 years, Vincent Van Gogh produced a torrent of work. Close to 1,700 of his works survive. Yet he sold only one painting in his lifetime, and that for an equivalent of only $80.

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Vincent

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The refuse turned up many fragments of the dark olive green bottles that usually contained ale, porter, and cider. Far less common are bits of the light olive green bottles that often held wine, and even more rare are fragments of the green case bottles that usually contained gin. Pieces of clay pipes, called Negro pipes in contemporary newspapers, were also found in the rubble. Apparently, whites preferred other ways of taking tobacco.

The midden also yielded many cut iron nails with machine-made heads, manufactured after the 1820s. These nails were used to build and repair the one-room frame slave cabins, which measured about 17 by 20 feet (340 square feet). The cabin possessed at least one glazed, shuttered window, at least one door with a stock lock, and a chimney with a dirt-floored hearth. The construction materials and amenities were superior to those of most Old South slave dwellings, which, according to historian Eugene Genovese, typically measured only 16 by 18 feet (288 square feet) and had only unglazed windows and stick-and-clay chimneys. Still, the Cannon's Point slave cabins must have been crowded, with seven or eight slaves living in each.

The relatively high quality of the Cannon's Point cabins and the regularity of the ration issues suggest that the planter family showed a paternalistic concern for the slaves they owned. Fellow planters regarded John Couper as a "wise and kind master," and even the ardent abolitionist Fanny Kemble commented on his humane treatment of his slave force. Nevertheless, there is evidence of slave resistance to Couper's authority. In her *Journal of a Residence on a Georgian Plantation*, published in 1863, Kemble reported a conversation with the planter in which he compared his slaves to the Irish, and "instanced their subserviency, their flattering, their lying, and pilfering, as traits common to the characters of both peoples." One of Kemble's servants told her that slaves at Cannon's Point had once conspired to revolt. Although this report cannot be corroborated, John Couper did indicate in a letter to a friend that slave resistance was not uncommon: "About crops, runaway Negroes, and other plagues I will not touch. . . ."

So even on Cannon's Point—where the slaves worked but a part of the day, were free to trade with local merchants, and lived in substantial dwellings—slavery was oppressive. As Frederick Douglass wrote in his autobiography, "I have observed this in my experience of slavery—that whenever my condition was improved, instead of its increasing my contentment, it only increased my desire to be free, and set me to thinking of plans to gain my freedom." □

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Nature marks Izaak Walton as a rank amateur more often than I had imagined. In 1654, the world's most famous fisherman before Ted Williams wrote of his favorite lure: "I have an artificial minnow . . . so curiously wrought, and so exactly dissembled that it would beguile any sharpsighted trout in a swift stream."

An early column (January 1977) in this series told the tale of *Lampsilis*, a freshwater clam with a decoy "fish" mounted on its rear end. This remarkable lure has a streamlined "body," side flaps simulating fins and tail, and an eyespot for added effect; the flaps even undulate with a rhythmic motion that imitates swimming. This "fish," constructed from a brood pouch (the body) and the clam's outer skin (fin and tails), attracts the real item and permits a mother clam to shoot her larvae from the brood pouch toward the unsuspecting fish. Since the larvae of *Lampsilis* can only grow as parasites on the gills of a fish, this decoy is a useful device indeed.

I was astounded this summer to learn that *Lampsilis* is not alone. Ichthyologists Ted Pietsch and David Grobecker recovered a single specimen of an amazing Philippine anglerfish, not after intrepid adventures in the wilds, but from that source of so much scientific novelty—the local aquarium retailer. (Recognition, rather than *machismo*, is often the basis of exotic discovery.) Anglerfish lure their dinner, rather than a free ride for their larvae. They carry a highly modified dorsal fin spine affixed to the tips of their snouts. At the end of this spine, anglerfish mount an appropriate lure. Some deep-sea species, living in a dark world untouched by light from the surface, fish with their own source of illumination: they gather phosphorescent bacteria in their lures. Shallow-water species tend to have colorful, bumpy bodies, and look remarkably like sponge- or algae-encrusted rocks. They rest inert on the bottom and wave or wiggle their conspicuous lures near their mouths. "Baits" differ among species, but most resemble—often imperfectly—a variety of invertebrates, including worms and crustaceans.

Pietsch and Grobecker's anglerfish, however, has evolved a fish lure every bit as impressive as the decoy mounted on *Lampsilis*'s rear—a first for anglerfish. (Their article in *Science*, July 28, 1978, bears as its appropriate title "The Compleat Angler" and cites as an epigraph the passage from Walton quoted above.) This exquisite fake also carries eyelike spots of pigment in the right place. In addition, it bears compressed filaments representing pectoral and pelvic fins along the bottom of the body, extensions from the back resembling dorsal and anal fins, and even

Ichthyosaur AMNH

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THE LIMITS OF EDITION. The *Game Birds of the World* porcelain plate collection will be produced only once and in strictly limited edition, with an absolute closing date of January 31, 1979. The plates will be crafted exclusively for individual subscribers. And the limit of one collection of Game Bird Plates per subscriber will be enforced without exception.

Thus, the total number of sets to be issued will be forever limited to the exact number of original subscriptions entered by January 31, 1979, plus one set for Basil Ede and one for the archives of Franklin Porcelain.

Since the plates will not be sold separately and will not be made available for original sale through dealers, the original subscribers and the artist will be the only people in the entir[e] world who can acquire this collection. In th[e] future, any dealer who may wish to offer thes[e] plates to a client, or any collector who ma[y] wish to acquire these plates at that time, ca[n] only hope to obtain them from one of the orig[i]nal subscribers.

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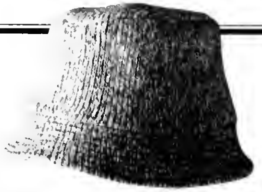

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an expanded rear projection looking for all the world like a tail. Pietsch and Grobecker conclude: "The bait is nearly an exact replica of a small fish that could easily belong to any of a number of percoid families common to the Philippine region." The angler even ripples its bait through the water, "simulating the lateral undulations of a swimming fish."

These nearly identical artifices of fish and clam might seem, at first glance, to seal the case for Darwinian evolution. If natural selection can do this twice, surely it can do anything. Yet, continuing the theme of the last two columns and bringing this trilogy to a close, perfection works as well for the creationist as the evolutionist. Did not the psalmist proclaim: "The heavens declare the glory of God; and the firmament showeth his handiwork." The last two columns argued that imperfection carries the day for evolution. This one discusses the Darwinian response to perfection.

The only thing more difficult to explain than perfection is repeated perfection by very different animals. A fish on a clam's rear end *and* another in front of an anglerfish's nose—the first evolved from a brood pouch and outer skin; the second from a fin spine—more than double the trouble. I have no difficulty defending the origin of both "fishes" by evolution. A plausible series of intermediate stages can be identified for *Lampsilis*. The fact that anglerfish press a fin spine into service as a lure reflects the jury-rigged, parts-available principle that made the panda's thumb and the orchid's labellum speak so strongly for evolution (see my November column, the first of this trilogy). But Darwinians must do more than demonstrate evolution; they must defend the basic mechanism of random variation and natural selection as the primary cause of evolutionary change.

Anti-Darwinian evolutionists have always favored the *repeated* development of very similar adaptations in different lineages as an argument against the central Darwinian notion that evolution is unplanned and undirected. If different organisms converge upon the same solutions again and again, does this not indicate that certain directions of change are preset, not established by natural selection working on random variation? Should we not look upon the repeated form itself as a cause of the numerous evolutionary events leading toward it?

Throughout his last half-dozen books, Arthur Koestler, for example, has been conducting a campaign against his own version of Darwinism. He hopes to find some ordering force, constraining evolution to certain directions and overriding the influence of natural selection. Repeated evolution of excellent design in separate lineages is his bulwark. Again and again, he cites the "nearly identical skulls" of wolves and the "Tasmanian wolf." (This marsupial carnivore looks like a wolf but is, by genealogy, more closely related to wombats, kangaroos, and koalas.) In *Janus*, his latest book, Koestler

Tasmanian wolf — AMNH

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writes: "Even the evolution of a single species of wolf by random mutation plus selection presents, as we have seen, insurmountable difficulties. To duplicate this process independently on island and mainland would mean squaring a miracle."

The Darwinian response involves both a denial and an explanation. First, the denial: it is emphatically not true that highly convergent forms are effectively identical. Louis Dollo, the great Belgian paleontologist who died in 1931, established a much misunderstood principle—"the irreversibility of evolution" (also known as Dollo's law). Some ill-informed scientists think that Dollo advocated a mysterious directing force, driving evolution forward, never permitting a backward peek. And they rank him among the non-Darwinians who feel that natural selection cannot be the cause of nature's order.

In fact, Dollo was a firm Darwinian interested in the subject of convergent evolution—the repeated development of similar adaptations in different lineages. Elementary probability theory, he argued, virtually guarantees that convergence can never yield anything close to perfect resemblance. Organisms cannot erase their past. Two lineages may develop remarkable, superficial similarities as adaptations to a common mode of life. But organisms contain so many complex and independent parts that the chance of all evolving twice toward exactly the same result is effectively nil. Evolution is irreversible; signs of ancestry are always preserved; convergence, however impressive, is always superficial.

Consider my candidate for the most astounding convergence of all: the ichthyosaur. This sea-going reptile with terrestrial ancestors converged so strongly on fishes that it actually evolved a dorsal fin and tail in just the right place and with just the right hydrological design. The evolution of these forms was all the more remarkable because they evolved from nothing—the ancestral terrestrial reptile had no hump on its back or blade on its tail to serve as a precursor. Nonetheless, the ichthyosaur is no fish, either in general design or in intricate detail. (In ichthyosaurs, for example, the vertebral column runs through the lower tail blade; in fish with tail vertebrae, the column runs into the upper blade.) The ichthyosaur remains a reptile, from its lungs and surface breathing to its flippers made of modified leg bones, not fin rays.

Koestler's carnivores tell the same tale. Both placental wolf and marsupial "wolf" are well designed to hunt, but no expert would ever mistake their skulls. The numerous, small marks of marsupiality are not obliterated by convergence in outward form and function.

Second, the explanation: Darwinism is not the theory of capricious change that Koestler imagines. Random variation may be the raw material of change, but natural selection builds good design by rejecting most variants while accepting and accumulating the few that improve adaptation to local environments.

The basic reason for strong convergence, prosaic though it may seem, is simply that some ways of making a living impose exacting criteria of form and function upon any organism playing the role. Mammalian carnivores must run and stab; they do not need grinding molar teeth since they tear and swallow their food. Both placental and marsupial wolves are built for sustained running, have long, sharp, pointed canine teeth and reduced molars. Terrestrial vertebrates propel themselves with their limbs and may use their tails for balance. Swimming fish balance with their fins and propel from the rear with their tails. Ichthyosaurs, living like fish, evolved a broad propulsive tail (as whales did later—although the horizontal flukes of a whale's tail beat up and down, while the vertical flukes of fish and ichthyosaurs beat from side to side).

No one has treated this biological theme of repeated, exquisite design more eloquently than D'Arcy Wentworth Thompson in his 1942 treatise, *On Growth and Form,* still in print and still as relevant as ever. Sir Peter Medawar, a man who eschews hype and exaggeration, describes it as "beyond comparison the finest work of literature in all the annals of science that have been recorded in the English tongue." Thompson, zoologist, mathematician, classical scholar,

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and prose stylist, won accolades as an old man but spent his entire professional life in a small Scottish university because his views were too unorthodox to win prestigious London and Oxbridge jobs.

Thompson was more a brilliant reactionary than a visionary. He took Pythagoras seriously and worked as a Greek geometrician. He took special delight in finding the abstract forms of an idealized world embodied again and again in the products of nature. Why do repeated hexagons appear in the cells of a honeycomb and in the interlocking plates of some turtle shells? Why do the spirals in a pine cone and a sunflower (and often of leaves on a stem) follow the Fibonacci series? (A system of spirals radiating from a common point can be viewed either as a set of left- or right-handed spirals. Left and right spirals are not equal in number, but represent two consecutive figures of the Fibonacci series. The Fibonacci series is constructed by adding the previous two numbers to form the next: 1, 1, 2, 3, 5, 8, 13, 21, etc. The pine cone may, for example, have 13 left spirals and 21 right spirals.) Why do so many snail shells, ram's horns, and even the path of a moth to light follow a curve called the logarithmic spiral?

Thompson's answer was the same in each case: these abstract forms are optimal solutions for common problems. They are evolved repeatedly in disparate groups because they are the best, often the only, path to adaptation. Triangles, parallelograms, and hexagons are the only plane figures that fill space completely without leaving holes. Hexagons are often favored because they approximate a circle and maximize area within relative to the supporting walls (minimum building for greatest storage of honey, for example). The Fibonacci pattern emerges automatically in any system of radiating spirals built by adding new elements at the apex, one at a time in the largest space available. The logarithmic spiral is the only curve that does not change its shape as it grows in size. I can identify the abstract Thompsonian forms as optimal adaptations, but to the larger metaphysical issue of why "good" form often exhibits such simple, numerical regularity, I plead only ignorance and wonder.

So far, I have only spoken to half the issue embodied in the problem of repeated perfection. I have discoursed on the "why." I have argued that convergence never renders two complex organisms completely identical (a circumstance that would strain Darwinian processes beyond their reasonable power) and have tried to explain close repeats as optimal adaptations to common problems with a few solutions.

But what about the "how?" We may know what the fish of *Lampsilis* and the lure of the anglerfish are for, but how did they arise? This problem becomes particularly acute when the final adaptation is complex and peculiar but built from familiar parts of different ancestral functions. If the angler's fishlike lure required 500 entirely separate modifications to attain its exquisite mimicry, then how did the process begin? And why did it continue, unless some non-Darwinian force, cognizant of the final goal, drove it on? Of what possible benefit is step one alone? Is a five-hundredth of a fake enough to inspire the curiosity of any real item?

D'Arcy Thompson's answer to this problem was overextended but characteristically prophetic. He argued that organisms are shaped directly by physical forces acting upon them: optima of form are nothing more than the natural states of plastic matter in the presence of appropriate physical forces. Organisms jump suddenly from one optimum to another when the regime of physical forces alters. We now know that physical forces are too weak, in most cases, to build form directly—and we look to natural selection instead. But we are derailed if selection can only act in a patient and piecemeal way —step by sequential step to build any complex adaptation.

I believe that a solution lies in the essence of Thompson's insight, shorn of the unsubstantiated claim that physical forces shape organisms directly. Complex forms are often built by a much simpler (often a very simple) system of generating factors. Parts are connected in intricate ways through growth, and alteration of one part may resound through the entire organism and change it in a variety of unsuspected ways. David Raup, of Chicago's Field Museum of Natural

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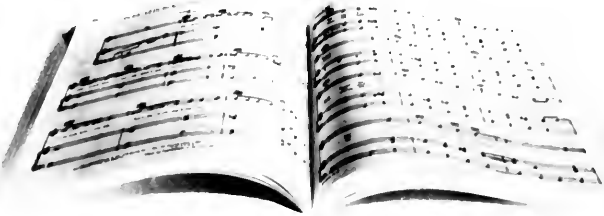

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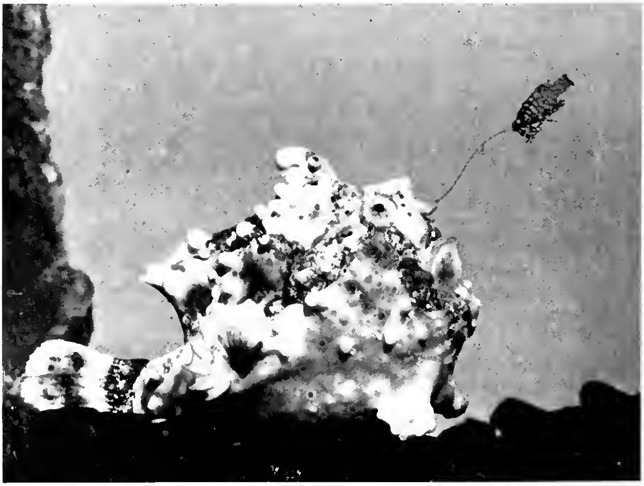
History, adapting D'Arcy Thompson's insight to a modern computer, has shown how the basic forms of coiled shells—from nautiloid to clam to snail—can all be generated by varying only three simple gradients of growth. Entire body plans may be rapidly altered by changing a few generating forces. Using Raup's program, I can change a garden-variety snail into a common clam by modifying just two of the three gradients. And, believe it or not, a peculiar genus of modern snails does carry a bivalve shell so like a conventional clam's that I gasped when I saw a snail's head poking out between the valves in a striking close-up movie.

This closes a trilogy of columns on the issue of perfection and imperfection as signs of evolution. But it is really an extended disquisition on the panda's "thumb," a single, concrete object that spawned all three columns, despite their subsequent wanderings and musings. The thumb, built of a wrist bone, imperfect as a sign of history, constructed from parts available. Dwight Davis, whose monograph on the giant panda may be this century's greatest work in evolutionary comparative anatomy, faced the dilemma of potential impotence for natural selection if it must work step by countless step to make a panda from a bear. And he advocated Thompson's solution of reduction to a simple system of generating factors. He showed how the complex apparatus of the thumb, with all its muscles and nerves, may arise as a set of automatic consequences following a simple enlargement of the radial sesamoid bone. He then argued that the complex changes in form and function of the skull—the transition from omnivory to nearly exclusive munching on bamboo—could be expressed as consequences of one or two underlying modifications. He concluded that "very few genetic mechanisms—perhaps no more than half a dozen—were involved in the primary adaptive shift from *Ursus* [bear] to *Ailuropoda* [panda]. The action of most of these mechanisms can be identified with reasonable certainty."

And thus we may pass from the underlying genetic continuity of change—an essential Darwinian postulate—to a potentially episodic alteration in its manifest result—a sequence of complex, adult organisms. Within complex systems, smoothness of input can translate into episodic change in output. And here we encounter a central paradox of our being and of our quest to understand what made us. Without this level of complexity in construction, we could not have evolved the brains to ask such questions. With this complexity, we cannot hope to find solutions in the simple answers that our brains like to devise.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.



Anglerfish

David B Grobecker

WHALE NOTES

1 A KILLER WHALE CAN make two vocal sounds at the same time.

2 BLUE WHALES make sounds that carry across entire oceans.

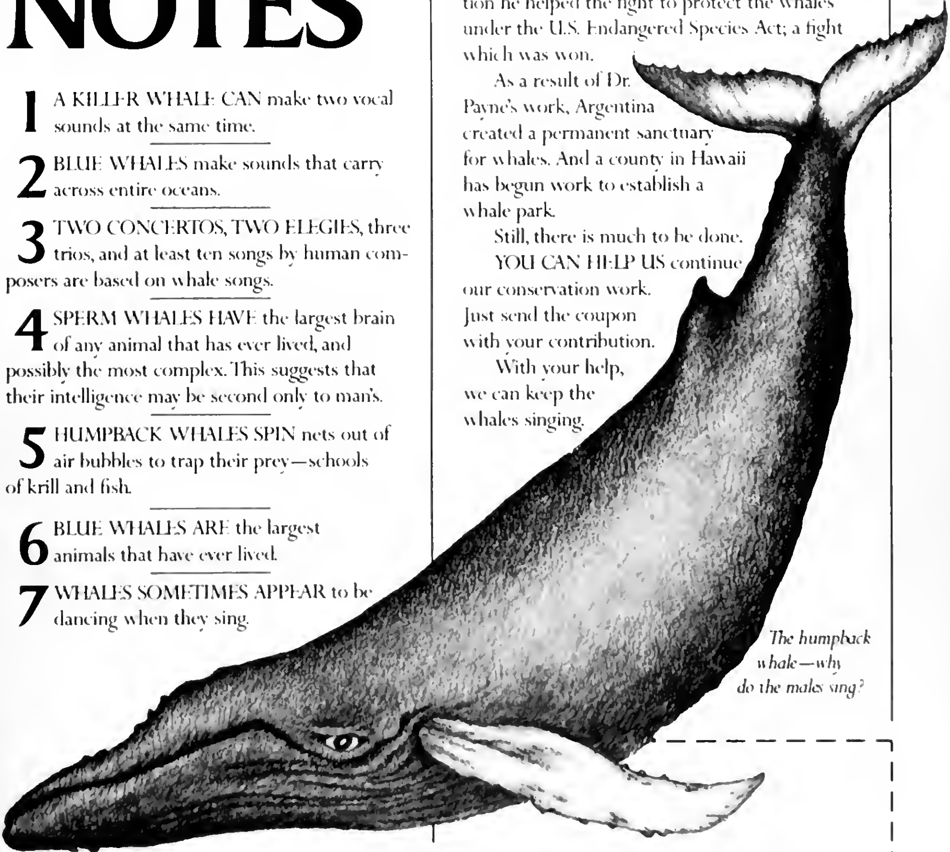
3 TWO CONCERTOS, TWO ELEGIES, three trios, and at least ten songs by human composers are based on whale songs.

4 SPERM WHALES HAVE the largest brain of any animal that has ever lived, and possibly the most complex. This suggests that their intelligence may be second only to man's.

5 HUMPBACK WHALES SPIN nets out of air bubbles to trap their prey—schools of krill and fish.

6 BLUE WHALES ARE the largest animals that have ever lived.

7 WHALES SOMETIMES APPEAR to be dancing when they sing.



The humpback whale—why do the males sing?

8 WHALES HELP SICK or wounded companions breathe by pushing them gently to the surface.

9 WHALES TOUCH AND COMFORT each other. Mothers often lie on their backs with their calves draped across their chests, patting them with their flippers.

10 LAST YEAR MAN KILLED 23,000 whales, to make such things as fertilizer, dog food, margarine, soap. For all whale products, there are ready substitutes.

11 MANY OF THESE NOTES on whales were gathered by Dr. Roger Payne of the New York Zoological Society. Using this information he helped the fight to protect the whales under the U.S. Endangered Species Act; a fight which was won.

As a result of Dr. Payne's work, Argentina created a permanent sanctuary for whales. And a county in Hawaii has begun work to establish a whale park.

Still, there is much to be done.

YOU CAN HELP US continue our conservation work. Just send the coupon with your contribution.

With your help, we can keep the whales singing.

I WANT TO HELP the NYZS preserve our environment and wildlife. Enclosed is my contribution of ____$5, ____$10, ____Other.

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Cultural Echoes Across the Mountains

by Robert E. Rhoades

The Swiss and the Nepalese have adapted to the highland environment in remarkably similar ways

Travelers to Nepal frequently describe the natural and cultural life of Himalayan valleys as "reminiscent of the Swiss Alps." The two areas are remarkably alike in their flora, rock formations, and architecture. In the glacier-fed highland pastures of both, summer huts stand on a carpet of primula, gentian, and edelweiss, and at lower altitudes, winding paths lead from rock-fenced hay meadows to weathered villages just above the valley floors.

In the villages, Swiss and Nepalese alike, carefully tended gardens adjoin large two-storied houses, whose gabled roofs are covered with broad pine planks and stone slabs. The upper levels of these houses provide living quarters, while the ground levels serve as stalls and storage areas.

Pots of bright flowers conceal the houses' intricately carved window frames. Inside, shiny brass and copper vessels dangle from finely carved wooden shelves near smoky open hearths, and rough tables and benches circle the main living area where hardy mountain peasants, European and Asian, center their social life.

Beyond these stylistic similarities, Switzerland and Nepal would at first appear to have little more in common than their mountain environments. The former is the epitome of modernization, while the latter is one of the world's least developed countries. Today, Nepal is struggling to establish a simple road system, while Switzerland's cantons are linked by modern highways and an extensive electric rail network. Most of Nepal is accessible only on foot; the Swiss, in contrast, can speed over 15,000 miles of track so rapidly that passengers complain of being unable to enjoy the mountain landscape. Nepal, where the per capita income is less than $120 per year, faces a vast development task, while Switzerland, with its industrial and commercial empires, is home to one of the world's greatest concentrations of wealth.

Yet despite enormous economic differences between these countries, the demands of their mountain environment have fostered many cultural similarities. Both countries have come peacefully to terms with internal diversity, allowing cultural differences to serve as objects of national pride rather than strife. Mountain geography has made each country a buffer state, sandwiched between powerful neighbors. Precariously positioned at the crossroads of Europe and Asia, both Switzerland and Nepal have fostered fierce political neutrality and independence. Historically, both countries have been affected by the defensibility of their crucial mountain passes. In addition, hydroelectric power and tourism have become increasingly important in both countries, threatening their environments while enhancing their incomes. And a sense of common struggle is recognized by both nations. In a recent proclamation, for example, the king of Nepal praised Switzerland as the political and economic model his country should emulate in future planning. Nepalese refer to their homeland as "the Switzerland of Asia," while the Swiss contribute the largest proportion of their foreign aid to Nepal.

Parallel cultural patterns can best be observed in the isolated mountain valleys. The terrains of northern Nepal and highland Switzerland yield similar kinds of rock and timber, which, as building materials, lend mountain architecture its characteristic appearance. Abruptness in topography can trigger avalanches or rock slides, dangers that force mountain peasants to cautiously locate their settlements and fields away from the paths of potential disaster. Short growing seasons and rocky, unproductive terrains limit agriculture. Mountain slopes in both countries characteristically contain tightly compressed vegetation belts, ranging from warm valley floors, through grasslands and coniferous forests, to zones of permanent snow. Human survival depends upon efficient exploitation of these narrow ecozones.

Given the constraints imposed by the mountain environment, highland societies have developed several strategies for coping with a vertical terrain where a single zone of production is insufficient to meet a population's demands. In many Eurasian mountain ranges, some cultures specialize in herding to the virtual exclusion of cultivation, and satisfy their agricultural needs through trade with farmers who live at lower altitudes. This exchange system thoroughly exploits all the available ecozones.

In another common mountain economy, known as agro-pastoral transhumance, or mixed mountain agriculture, communities combine farming and herding at different altitudes. Transhumance, the seasonal trek of livestock and herders between the valley floor and high pastures, has occurred throughout

Terraced gardens and fields surround a village in Nepal. Using mixed mountain agriculture, upland people in both Switzerland and Nepal are able to exploit all levels of land, from the valley floors to the alpine meadows.

Jonathan T. Wright

the Scandinavian mountains, across the Alps, along the Eurasian mountain system through the Himalayas, and on into the inner mountains of China.

Mixed mountain agriculture is especially important in the Swiss canton of Valais and in Himalayan valleys such as Langtang and Khumbu, located north and northeast of Nepal's capital, Katmandu. In these glacial valleys, the seasons of long, cold winters and short, warm summers determine the rhythm of all life. Since the soil remains frozen for six months of the year, mountain families must depend for their food on a restricted cultivating and herding period lasting from mid-April to early October. The high-altitude zones are habitable and productive only during the brief summer, when haymaking, cultivating, stock grazing, and wood collecting yield or enhance resources that are taken to the main villages in preparation for the coming winter.

Each altitudinal zone serves a different purpose in the mountain transhumant economy. Main villages are located at lower altitudes just above the valley floor, where fields and small gardens are cultivated in fertile soil. The gently sloping meadows above the villages are used for early spring and late fall grazing and for the production of hay throughout the summer.

Willi P. Burkhardt Fotograf

Communal evergreen forests far above the main settlements supply firewood and building materials. Located even higher, between the forests and the zone of permanent snow, are the glacier-nourished pastures where village livestock graze during the summer.

The agricultural year for both the highland Swiss and the Khumbu Sherpa begins in late spring when villagers work the earliest thawed fields below the main settlement. As the thawing progresses up the slopes, cultivators gradually advance toward the highest fields, preparing the soil, sowing wheat or barley, and planting potatoes. Meanwhile, vegetable gardens are cultivated near the villages. As tillers work the fields, herders with yaks, cattle, goats, or sheep begin a gradual ascent toward the summer pastures. They first stop to graze their animals on the lower meadows and then, as the snow retreats, move on toward the high pastures, where they live until fall in summer huts (German: *Alphütte;* Sherpa: *yersa*). When cold weather again threatens the highlands, the herdsmen slowly drive their animals homeward, allowing them to forage on the lower meadows.

The descent of the herds in late August coincides with the ascent of harvesters who, starting at the lowest fields, follow ripening grain steadily up the mountainside. A few feet of elevation can make a difference of one or two days in the maturation of the crop, allowing a stepwise progression of harvesting activities.

By late September, the last grain is reaped and the final loads of hay are brought to storage. Only after harvest is complete are the animals permitted to come near the main village. Before the onset of winter, the herds are grazed on the stubble and allowed to manure the fields. The agricultural season comes to a close with the first heavy snows, at which time the herds are brought to the stables. In some Alpine and Himalayan valleys, the animals are stabled in winter huts located below the main villages and well protected from the icy blasts of glacial winds.

In this Swiss and Sherpa mountain agricultural cycle, all segments of the subsistence economy are intricately meshed. The system requires a complex, cyclical movement of men and animals following suitable climates; the upward migration in summer is a pursuit of sun and forage, and the fall retreat is a

Among the similarities between Swiss and Nepalese mountain society is the architecture of village houses. Families live above the stables in two-storied homes in Kandersteg, Switzerland, left, and Gurja Himal, Nepal, below. The land at a relatively low altitude is usually privately owned and used for summer crops and spring and fall grazing. Upland for summer grazing is held by the community.

search for protection from winter's harshness. This pendulum rhythm unites the alpine pastures and the valley floor and gives mountain agriculture its characteristic ecological design.

To facilitate these intricate movements, Sherpa and Swiss highlanders have developed the same patterns of land use and ownership. Typically, community law allows private ownership of small, cultivable fields and hay meadows located near the main village, while upland forests and alpine pastures are held in common. This land-tenure system reflects the special requirements of the mountains. Because garden plots and hay meadows demand intensive care, they can be efficiently exploited by private households; however, successful grazing in the high pastures and use of the forests require a coordinated effort. Uncontrolled cutting of trees could leave the community without essential firewood or building material and overgrazing on the high pastures could lead to dangerous and irreversible erosion above the village. More-

Gary Wolinsky, Stock

Left, a Nepalese man gazes out a window of a house in the Katmandu Valley. Below, a traditional farmhouse in Switzerland's Oberland Valley is decorated with flowers and ivy during the brief summer respite from winter bleakness. Carved window frames and plants typically adorn both Himalayan and Alpine homes, which are built of similar materials found in both mountain ranges.

Swiss National Tourist Office

Peasants in the canton of Valais, Switzerland, top, and Sherpa in Nepal, bottom, use similar pack baskets. Many Swiss and Sherpa supplement their incomes by serving as guides and porters for tourists. The strength and fierceness of these mountain peoples have also earned them positions in foreign mercenary armies, such as the Gurkha regiments of the British army.

N.A. Callow NHPA

over, if the high pastures were parceled out to private owners, some villagers might be blocked from access to summer pasture or, worse yet, end up without a stake in this economic zone.

In many mountain valleys, traditional communities are reluctant to sell any land to outsiders, and only meadows and tillable parcels are bought and sold among the villagers. Mountain inhabitants maintain strict control over land-use rights not simply out of an emotional "love of the land," but because ecological conditions require careful protection of valley resources and close coordination of agro-pastoral practices.

In addition to its gardens and its share in the commons, a single household may own six to eight parcels of land located at different elevations. This dispersion of plots reduces the risk of a complete crop failure. Because of the varied nature of the terrain, a poor yield at one level does not imply the same result in another part of the valley. Likewise, an avalanche or mudslide may damage only a small portion of a household's land. In addition, because crops are planted and ripen according to their altitude, cultivation and harvesting can be accomplished without hiring extra labor. A family can follow a staggered work schedule determined by the natural maturing of the crops, a pattern that would be impossible on flatland where crops ripen at approximately the same time. This fragmentation of holdings also serves to make sure all households have access to soil types of varying quality. If, for example, a few families owned all of the fertile plots in the lower valley, then other peasants would be restricted to the low-yielding, shallow-soiled fields at higher elevations.

Analogous Himalayan and Alpine social patterns further demonstrate a concern for cooperation. The essential element of village government, whether Swiss or Sherpa, is that authority is vested in all community members. During the annual spring assembly, the citizens democratically vote on village regulations. The famous Swiss open-air assembly, known as *Landsgemeinde*, may be the forerunner of Swiss democracy. The Sherpa have developed a similar village assembly, called *yul-thim*, or "village law." In both countries, at a community meeting convened in late April or early May, depending on the weather, villagers select from among their own ranks one or two leaders who will serve a one-year term. Over time, the leader

Jonathan T. Wright

Diane Lowe, Stock

Above, a woman milks a yak near an isolated herder's summer hut in Himalayan pastureland above Bhote Kosi, Nepal. Left, a highland pasture looks down on Grindewald, Switzerland. In spring and early summer, Swiss and Nepalese herders and their livestock follow the retreating snow up the mountainsides. They remain in alpine pastures until early fall, when cold weather forces them down to lower meadows and, eventually, to their villages.

office rotates among the various household heads and functions to draw all families into community decisions. The village as a unit decides when, how far, and how many animals shall move to pasture; when and what crops shall be planted; and how cleaning of irrigation channels, cutting of trees, and related activities shall be carried out.

The appointed guardians, or wardens, enforce these rules with the threat of punishment. Above all, they encourage civic responsibility and total community harmony. Alpine villagers know through experience that a single irresponsible decision could expose man and animal to the deadly grip of an early winter storm, and that one night's foraging by animals on unharvested crops could deplete the year's grain supply. In short, social control among mountain men is as rigorous as the alpine habitat itself.

Similar Sherpa and Swiss rituals and legends reflect the need to promote village harmony and coordinate agro-pastoral activities. Mountain folk beliefs and cere-

monies have been strongly influenced by Christianity in Switzerland and Buddhism in Nepal, and they also seem to serve important functions in village economic life. In Alpine and Himalayan valleys, population pressures and limited land have induced a high percentage of village youth to opt for celibacy and the monastic way of life; this prevents excessive fragmentation of familial lands and fosters the spiritual life of the community. The Christian and Buddhist ceremonial calendars provide structure for the annual cycle. For example, saint's or lama's days mark the beginning and the termination of the summer's herding. These rituals build group solidarity before the long summer separation of families, bring together villagers who need to replenish herds or market their products, and insure that the migrations and cultivating activities keep on schedule.

In early spring, a series of community festivals is held in both the Alps and the Himalayas. In addition to the annual village gathering where leaders are elected and decisions are made about the herds, other celebrations include ritual cleansings of evil spirits, blessings over newly sown crops, and send-offs for herders and herds. The spring fetes are characterized by joking, drinking, flirting, and horseplay, along with opportunities to discuss and resolve problems within or between families. During the summer, after the herds have ascended to the higher pastures, a Buddhist lama or a Catholic priest climbs the mountain to deliver a benediction. In the Swiss Alps' Val d'Anniviers, for example, the curé of Sissoye treks to the high pastures and holds a service, for which he is presented with a gift of cheese. The Sherpa ritualistic counterpart is known as *yer chang* ("summer beer") and is intended to protect the herds. In this ritual, the animals are decorated and the pastures are blessed by a lama. In both regions, this celebration on the summer pastures is the final group gathering of any kind before the herders disperse to their huts. No community festival will be held until the fall, when the herds and herdsmen return and the harvest is finished.

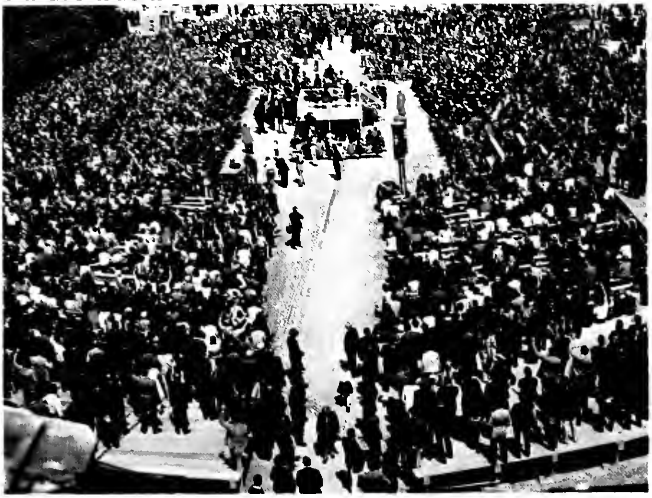
Lowlanders have always been amused by the religious customs and intensely superstitious nature of mountain people. The mountain crosses, cairns, and prayer flags along Himalayan and Alpine trails are highlanders' attempts to appease their gods. In the Alps of traditional Switzerland, an evening prayer was always sent echoing to distant pastures from the long alpenhorn. Interestingly, similar ceremonial horns, six to ten feet long, can be found in the Himalayan Khumbu, as well as in other Eurasian mountain ranges.

Given the precarious mountain terrain, a world rich in unpredictable spirits and man-animal beasts may be more practical than meets the eye. What better reason to keep people inside after dusk or on well-known paths than the threat of an abominable snowman or of such Yeti-like creatures as Widma or Wildwyb lurking in wait for the unwary? With legends telling of every variety of monster inhabiting the dark crevices, a herder will think twice before searching for a

Keith Gunnar West Stock

Potatoes are cultivated in privately owned gardens near villages in Nepal, upper right, and in the Tal Valley of the Austrian Alps, right. In early summer, as the herds climb to their high pastures, farmers plant wheat, barley, hay, and potatoes. Crops are harvested in late summer and early fall. Just a few feet of elevation can affect crop maturation by one or two days, allowing the harvesters to work in steps up the slopes.

Swiss National Tourist Office



At annual spring assemblies in villages in Switzerland, left, and Nepal, bottom left, communities elect their leaders for the next year and make decisions about issues affecting the common welfare. In these mountain villages, authority is vested in all residents. Each family is expected to take part in community activities and to share responsibility. Harmony and cooperation are vital in such a rigorous environment.

Robert Weinreb

lost calf over the steep, dangerous mountainside.

Traditional mountain cultures have not totally escaped change or the influence of the modern, outside world. Population pressure on the limited land has always forced highlanders to explore opportunities for supplemental income far from their home valleys, especially during the idle winter months. Long-distance trade, handicraft marketing, and wage labor in distant lowlands have been important as has service as mercenaries in foreign armies.

Just as the Atlas Berbers are frequently called the Gurkhas of Africa, so might the fighting Gurkhas of Nepal be dubbed the Swiss of Asia. Despite their reputation for peaceableness, the Swiss fought *pas de Sous, pas de Suisses* ("no pay, no Swiss") in every European war for several centuries. When the Hapsburgs failed to conquer the hardy mountaineers, they hired them. Today, the Swiss Guards at the Vatican are the only vestige of that stage in Swiss history.

In Nepal, Gurkha regiments were formed in the nineteenth century when the British decided that Nepalese soldiers made better comrades than enemies. Until recently, pay and pensions from foreign armies provided the major source of Nepal's outside income, as was the case in fifteenth-century Switzerland.

A century ago in Switzerland and two decades ago in Nepal, foreign tourism began to play a major role in these highland economies. Tourism developed along similar lines in both countries: eccentric adventurers and alpine climbers came first, followed by organized mountaineering expeditions and then by nonclimbing tourists. The influx of foreign mountain enthusiasts created new occupations for the highland Swiss and Sherpa. When Nepal was opened to the outside world in the 1950s, Westerners—mainly the British—came to admire and conquer the Himalayas, as they had the Swiss Alps a century before. Taking advantage of these new employment opportunities, the Sherpa established mountaineering associations and guide services comparable to the famous Swiss Corporation des Guides, created for similar reasons in the nineteenth century. Today, most outside income of the Sherpa is derived from expeditions and trekking tours. Virtually all of the world's legendary mountaineering guides are Swiss or Sherpa, who have demonstrated remarkable bravery on the peaks and fierce loyalty to their employers. But first they had to overcome their puzzled

view of the strange foreigners who expressed an insane desire to conquer the malevolent peaks where only spirits and gods lived.

While it brings in money and creates local employment, tourism can promote deterioration of the countryside's environment. In some areas of the European Alps, pastures are no longer dotted with summer huts but marred with the concrete structures of a massive recreation industry: hotels, gambling halls, restaurants, and ski lifts. Seasonal visitors who rush to the highlands are not interested in living like the local peasants; their demand for lowland comforts requires the imposition of elaborate, modern physical plants upon ancient mountain villages. Litter and pollution are unavoidable byproducts.

Frequently, mountain inhabitants sell their ancestral land to lowland entrepreneurs and depart permanently for a distant city. The agrarian exodus has become so acute in parts of the Alps that the old mountain economy has been reduced to the status of a tourist poster. In the Bavarian Alps, this undesired transformation has reached crisis proportions. In a play on German words, some call the situation a true *Alptraum* ("nightmare"), and many Swiss fear that the Alps may soon deteriorate into mere shadows of their former beauty if no controls are imposed on tourism.

Nepal is just now confronting mass tourism, having moved from a trickle of tourists twenty years ago to today's multimillion dollar per year business. Katmandu is becoming a sea of hotels. Packaged tours and organized treks abound. Even in isolated Khumbu, tourism has arrived in full force. Using Sherpa labor, the Japanese have constructed an exotic hotel with its own view of Mount Everest. Piles of litter grow along the trails to the high pastures, and yak herders ascend in fewer numbers every year. Reportedly, tin cans, toilet paper, photographic wrappings, and other debris of modern life make some areas look like a field after a rock concert. Despite substantial profits, the Swiss and other Alpine Europeans have learned that unbridled tourism has its aesthetic and ecological disadvantages. The Nepalese are just now beginning to see that the benefits of tourism do not come without costs.

Tourism is only one threat to the ecology of the Alps and the Himalayas. Modernization—the construction of roads, bridges, and hydroelectric dams—has its price, too. The Sherpa long ago learned that uncontrolled cutting of timber and reckless overgrazing of pastures are damaging on mountains—much more so than on flatlands. Even seemingly harmless changes on steep slopes may lead to irreversible erosion, which first affects the highlands and later may bring widespread destruction to watershed areas on plains far below. Mountains are finely tuned habitats particularly sensitive to human activity.

While development of roads and dams may open isolated valleys and harness water energy in a world of finite fossil fuels, it can also speed devegetation and thus degradation of the slopes. Ecologically ill-conceived pursuits not only irreparably scar the natural beauty of mountains but may ultimately create eroded wastelands incapable of sustaining any human life at all.

We should be able to learn from the examples of denuded hillsides found around the Mediterranean and in Appalachia, where decades of myopic exploitation have taken a disastrous toll. A similar fate awaits other mountain systems where people fail to understand the fragile composition of the upland habitat.

As economic development and

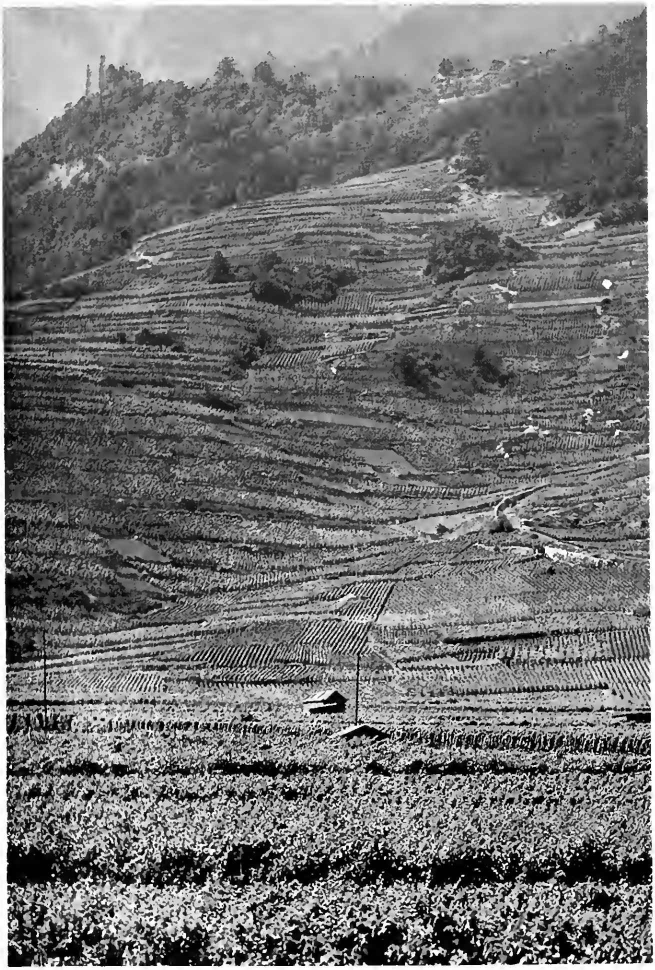
Many rituals and customs are common to Himalayan and Alpine communities. The only difference between the long ceremonial horns used in both regions is that the Nepalese horns, below, are not curved near the bell. In highland environments, where so many important matters are controlled by weather and a precarious terrain, religion and ceremony are especially important.

Willi P. Burkhardt

population growth continue to threaten the stability of the world's mountain lands, the question of how to prevent further environmental deterioration becomes increasingly urgent. Unfortunately, innovative planning is hampered by lack of understanding about how humans adapt to and influence mountain ecosystems. Typically, modern development programs in many hilly and mountainous areas, especially in underdeveloped countries, are naïvely predicated on lowland and flatland assumptions about how life should be arranged.

A comparative understanding of how indigenous mountain societies have survived for centuries might provide planners with a different approach to the problems of development from that of their own flatland perspective. Although mountain groups, such as the Swiss and Sherpa, have not always acted as perfect conservationists, they have, through long-term adjustment and accommodation, developed special insights worth incorporating into mountain development schemes. Their struggle with highland conditions has created a cooperative spirit that stresses that every valley inhabitant has a civic duty to protect village lands and insure the smooth coordination of economic and social activities. Correspondingly, there are sanctions against individual exploitation for personal gain at the expense of the environment or community well-being. The rigorous village watch over the cutting of trees, grazing of pastures, and ownership of property is grounded in the knowledge that preservation of natural resources is a life and death matter.

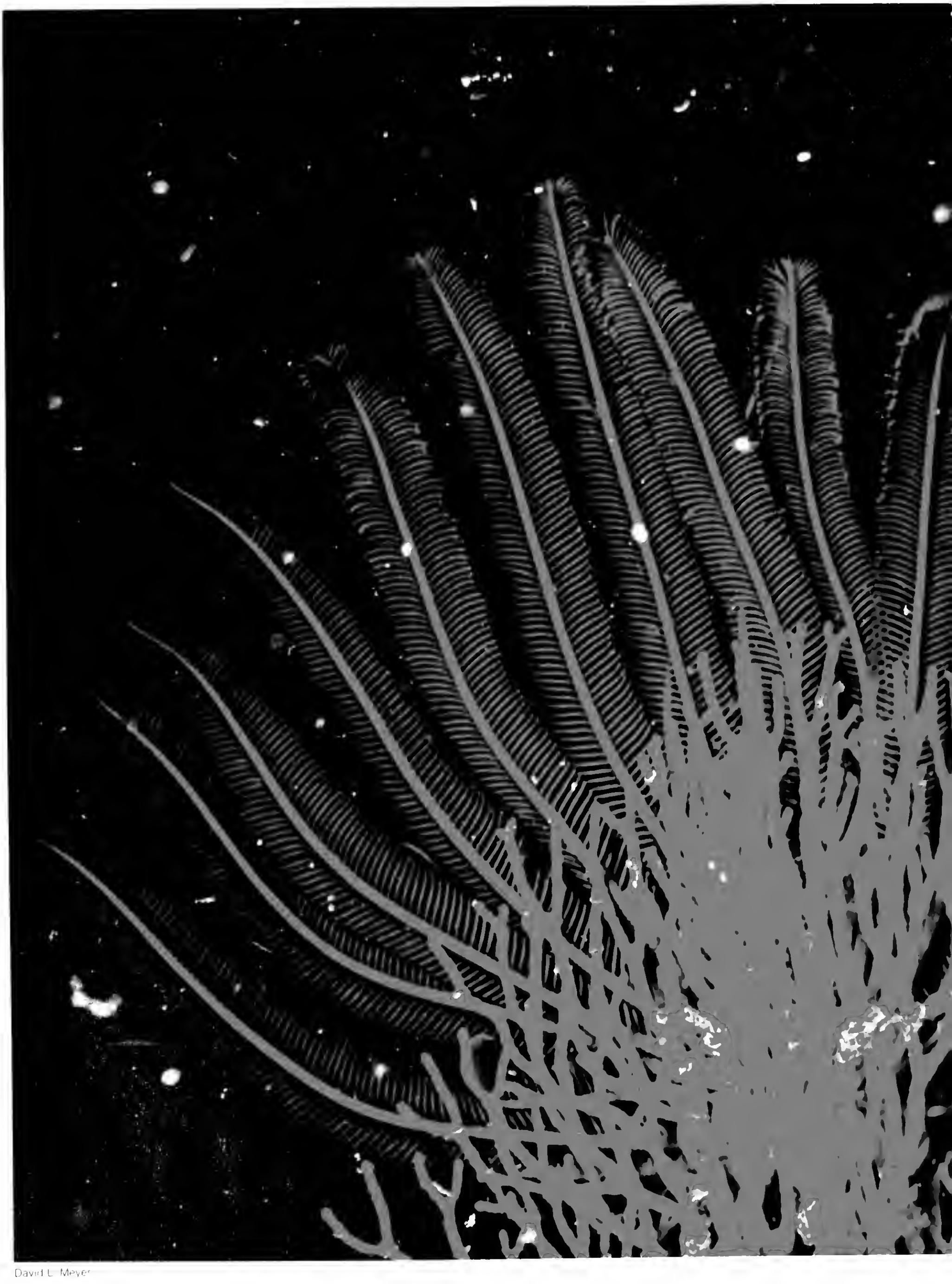
Unfortunately, traditional insights and wisdom based on ancient mountain adaptations are rapidly passing in Switzerland and Nepal. The exodus of mountaineers to the lowlands and the influx of vacationing plains dwellers to the highlands may insure the demise of the old mountain way of life in a not-too-distant future. Yet scientists and planners still have a unique opportunity to learn from surviving mountain people about resource management, land use, forest control, erosion prevention, and agricultural practices. Highland folk are not marginal, anthropological curiosities, but rationally adapted people who have long struggled to survive in one of nature's most difficult and demanding environments. The future of not only the Alps and Himalayas but of all hill and mountain habitats threatened by environmental deterioration may hinge on how well we achieve this understanding of the human element in mountain ecology. □



Cary Wolinsky, Stock

Whether viewed from below in Switzerland, left, or from above in Nepal, right, the stark verticality of mountain geography clearly dominates highland life. The elaborate seasonal migration between the valley floor and the high pastures has provided the basic means of survival for indigenous mountain communities in both countries for centuries. Tourism and modernization threaten to undermine the ancient stability of the social system as well as that of the mountains themselves.

Carl Purcell, Photo Researchers



David L. Meyer

Alive and Well after Millions of Years

by David L. Meyer and D. Bradford Macurda, Jr.

Diving studies of living crinoids, marine survivors from ancient times, may throw light on the life of their ancestors

Among marine invertebrates that were plentiful during the Paleozoic Era, from about 500 to 225 million years ago, are a group of flowerlike animals known as crinoids. In their heyday, these creatures were so abundant that their fossilized skeletal fragments often form 100-foot limestone layers that may cover hundreds of miles of ancient sea floor now above sea level. More than 5,000 fossil species have been identified, but only the species of two life forms of this ancient group survive today—the stalked sea lilies and the unstalked feather stars.

While a great deal is known about the evolutionary history of the crinoids, until recently, little has been known about the ecology of the surviving representatives. As early as 1699 a Welsh naturalist realized that modern counterparts of crinoid fossils existed in the seas. In his time, living specimens of sea lilies were occasionally pulled up with fishermen's gear or washed ashore after storms. But not until the advent of deep-sea expeditions in the late nineteenth and early twentieth centuries was extensive knowledge of the variety and abundance of living crinoids acquired.

Since the deep sea held such a wealth of new discoveries, these pioneering expeditions concentrated on collecting from great depths. When sea lilies were recovered from depths of several thousand feet, they were hailed as living fossils because of their resemblance to some extinct crinoid forms. Even though many living crinoids, particularly the stalkless, free-swimming varieties, are common in relatively shallow water, the notion grew up that modern crinoids are restricted to great depths and, because of their comparatively few species, are probably on the road to extinction. Nowhere in the present seas have crinoids been found in the profusion of ancient times although they may be numerically important members of some marine communities.

The development during the last thirty years of such new techniques of submarine exploration as scuba diving, deep-sea photography, and research submersibles has revolutionized marine biological research. It is now possible to make direct observations of marine organisms in their natural environments—many of which cannot be reached by conventional dredging and trawling methods.

In the early 1960s, a German biologist, Dietrich Magnus, using scuba equipment in the Red Sea, was the first to make direct observations of living crinoids. Since the late 1960s, we have been diving and studying these animals in the Caribbean Sea and the Indo-Pacific region. In addition to enlarging our knowledge of living species, the studies are also providing us with useful analogies for the reconstruc

Most feather stars live in shallow waters on tropical coral reefs. These well-camouflaged examples fastened to Australia's Great Barrier Reef were photographed at a depth of 50 feet.

Sea lilies, the stalked crinoids, are generally bottom-dwelling, deepwater animals. Those shown at right were found below 600 feet. They are in the feeding position, which resembles a parabolic radar screen. The crown is tilted perpendicular to the current and the arms are curved into the current.

tion of such things as the feeding habits of the ancient crinoids.

All crinoids once had stalks, but about 200 million years ago one group, the feather stars, began to lose their stalks and to develop a complex musculature in their arms. Whereas the stalked sea lilies predominated in ancient times, most of today's living crinoids are stalkless, mobile feather stars. About 485 species have been identified.

Feather stars live in many different marine environments, from the poles to the tropics and from shallow intertidal waters to abyssal ocean depths of more than 20,000 feet. Their greatest variety, however, is found on tropical coral reefs and continental shelves at depths of less than about 300 feet.

The stalked sea lilies, on the other hand, now a minority with only 74 known species, are nevertheless much more reminiscent of the ancient crinoids. Their segmented stalks, like those of their ancestors, keep them raised above the sea bottom. Present-day sea lilies are restricted to depths greater than about 300 feet; they sometimes coexist with feather stars at depths of about 600 to 800 feet.

Today's stalked sea lilies are generally permanently fixed at a single location. Their immobility may be a liability for these animals, putting them at the mercy of predators and rough water conditions. If torn loose from their holdfasts, or roots, stalked crinoids can be swept away by currents. Some, like those we observed off Jamaica, have rows of clawlike appendages along the stalk, which attach to the sea bottom. Should the stalk break above the attachment, the crinoid might be able to reattach if the appendages catch on the sea bottom as the animal is carried along by the current.

Unstalked feather stars, on the other hand, use their strengthened arms to crawl or swim away from unfavorable situations and can relocate more easily should they be dislodged from their living sites. Their mobility may also enable them to escape from some types of predators. These advantages may account for the population reversal between stalked and unstalked crinoids that has taken place since ancient times.

Whether or not they possess a stalk, all living crinoids have similar modes of feeding. Along with a host of other marine organisms, such as sponges, corals, and clams, crinoids are suspension feeders rather than active hunters; they obtain their food by capturing living microorganisms, which are either swimming by or suspended in the vicinity by the turbulence of water currents. In a sense, crinoids are animated sieves, or fishing nets, trapping their food as it passes by.

The soft body of the sea lilies is enclosed within a calcareous, plated cup surmounted by a crown of arms, which may number from a minimum of five to as many as two hundred. Made of hard, segmented plates, the arms are covered with delicate projections, called pinnules, also made of plates, which

D Bradford Macurda Jr

Stalked crinoids date back about 500 million years to the Paleozoic Era. A colony of fossilized crinoids entombed in a slab of rock more than 300 million years old was unearthed in Iowa.

W K Sacco

create the featherlike appearance of these animals. Feather stars also have multiple, plated arms covered with pinnules, but their cups are smaller. A series of food grooves runs along the arms and the pinnules, converging on the mouth.

The principal feeding organs for all crinoids are minute tube feet that line the food grooves on the pinnules. In other, related marine invertebrates, such as sea stars and sea urchins, the tube feet end in suction cups used for locomotion, but the tube feet of crinoids lack such specialties and serve only for food capture and respiration. When the crinoid's tube feet are extended, their tips nearly touch each other, forming an effective food-trapping net. When food particles strike the tube feet, the feet lash violently back and forth, packing microorganisms into the animal's food grooves through which they are carried along to the mouth.

While modern feather stars have not surpassed the stalked crinoids of Paleozoic times in abundance or diversity, their mobility enables them to seek out feeding perches—areas elevated above the sea bottom—which provide good exposure to passing food-laden currents. Perches may be rocks, stony corals, sponges, soft corals, sea fans, sea grass, and even beer cans. Thus, in many cases, feather stars live elevated above the bottom, mimicking their stalked ancestors by perching on convenient objects.

Many feather stars are current seekers and form their feeding nets perpendicular to moderate currents, usually of less than two knots. Other feather stars are current avoiders, hiding within crevices with only their extended arms exposed. Current-avoiding crinoids do not form feeding nets but deploy their arms radially, a feeding method that may be well suited for meandering currents slower than one knot.

One of the biggest surprises revealed by our diving studies is that many species of feather stars work a night shift, extending their arms for feeding only after darkness and retreating into hiding by day. Magnus first reported this behavior in Red Sea crinoids; since then we have observed it in the Caribbean, the western Pacific, and the Indian Ocean. Nocturnal activity may be related to the avoidance of daytime predators or possibly to a food supply enriched by nighttime plankton migrations. Curiously, crinoids that feed around the clock live side by side with the nocturnal species, raising a new question about these animals—do different species that live together feed on the same or different types of planktonic food?

To a fossil collector used to the drab grays or whites of ancient stalked crinoids, the profuse color patterns of living feather stars are another surprise and puzzle. As yet we know very little about the biochemical origin and possible biological function of crinoid coloration. While the colored spots and bands of some feather stars enable the animals to blend into the variform background of a reef, other bright, solid-color species stand out against the drab coral. By analogy with other organisms, we suspect that some crinoid color patterns are protective attention-getting devices that have evolved to alert potential predators to possible crinoid distastefulness or toxicity.

In an early field study of crinoids, the American naturalist Hubert Lyman Clark reported in 1915 that fishes of the Torres

Overleaf: The delicate arm projections that give feather stars their name can be seen in these two specimens found in the Palau Islands in the western Pacific.

Straits, at the northern extremity of Australia's Great Barrier Reef, generally avoided feather stars. He proposed that feather stars might be toxic to these potential predators. Our observations tended to confirm Clark's report, although evidence exists that some fishes probably do prey on crinoids. The remains of feather stars have been found in fish stomachs, and we have frequently seen crinoids with broken arm tips that appear to have been nipped by fishes. At the base of their arms, many species of current-seeking feather stars possess specialized enlarged and spiny pinnules, which form a dense barrier around their soft bodies and probably serve to protect the vulnerable body from attacks by predators. Actual predation is rarely observed, but crinoids do not seem to be totally without natural enemies.

In 1972 we made the first direct observations of living stalked crinoids—the sea lilies—at depths of 400 to 1,000 feet. Diving off the northern coast of Jamaica in the *Nekton Gamma*, a seventeen-foot-long, two-man research submersible, we were part of a larger investigation of the geology and ecology of the deep reef slope below the shallow, species-rich coral reefs in those waters. Cramped into this tiny submarine, we descended about 400 feet through a twilight zone into a world of pitch blackness, below the depths attainable with conventional free-diving equipment. The *Nekton*'s powerful lights revealed an abundance of large sea lilies and feather stars on the sandy slope and rubble below the precipitous reef face. What we saw of sea lily behavior held new surprises that may provide meaningful insights into the modes of life of the ancient stalked crinoids.

Paleontologists traditionally en-

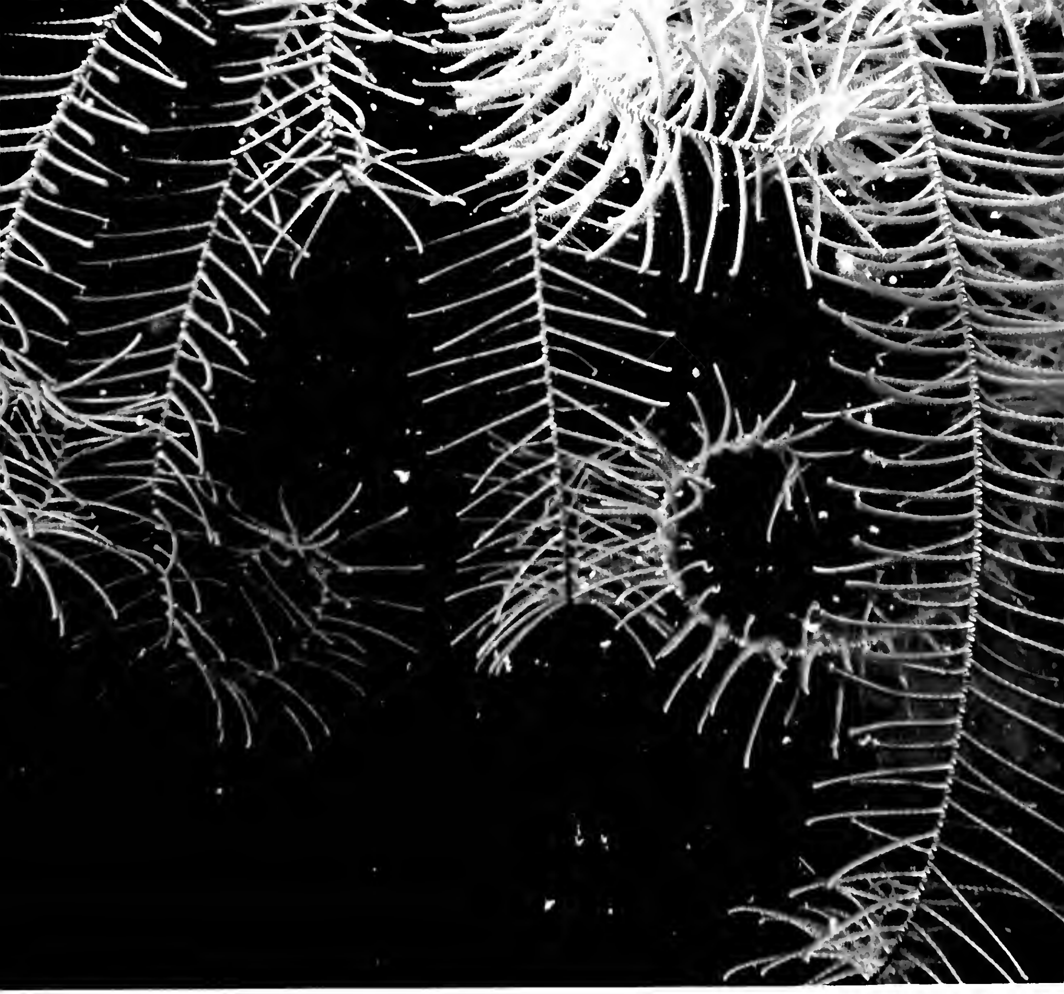
All photographs David L. Meyer

visaged stalked crinoids as extending their arms upward like an inside-out umbrella to form a feeding net that caught food particles falling vertically by force of gravity. Taking into account the first direct observations of living feather stars made by Magnus, the Dutch paleontologist Albert Breimer proposed in 1969 that ancient stalked crinoids probably instead formed feeding nets that were perpendicular to horizontal currents. Our observations of Jamaican stalked crinoids provide considerable support for Breimer's hypothesis.

When no currents were flowing, the Jamaican stalked crinoids resembled wilted flowers, with their crowns held upright and their arms curving downward. During periods of weak current flow, however, the crowns were tilted perpendicular to the current and the arms curved against, instead of with, the current. Thus the feeding behavior of these sea lilies is similar to that of the current-seeking feather stars in that their feeding nets are oriented according to prevailing currents. One difference, however, is that the feeding nets of feather stars are flat whereas those of sea lilies are parabolic, like radar screens. Nevertheless, in both cases the animals' arms withstand the flow of water currents, instead of bending with them, thereby demonstrating the strength of crinoid arm muscles. If we had deduced the direction of current flow solely from observation of the crinoids' arms, without resort to instruments, we would have been 180° in error, assuming the direction to be the exact opposite of what it actually was.

While we do not yet understand why the arms are curved counter to the current, we have observed similar orientations in Indo-Pacific feather stars and in such other marine invertebrates as sea fans and sponges. The knowledge that living feather stars and sea lilies respond to the prevailing horizontal currents along the sea bed, rather

Some feather stars, like the one at far left, hide within the spaces of coral ledges with only their arms protruding. Other feather stars perch in the open, sharing a reef with the local fish (below). When no current is flowing, the animal's arms are curled up instead of extended (left).



than to a supposed vertical rain of food particles, leads us to surmise that ancient crinoids may have exhibited similar behavior. We are now able to examine crinoid fossils from a more realistic point of view when attempting to reconstruct their past environments.

Much evidence, both sedimentary and paleontological, suggests that ancient stalked crinoids of the types known to most fossil collectors lived in very shallow depths some 500 to 225 million years ago when shallow seas covered vast regions of today's continents. If we were able to step into a time machine and dive with scuba gear into such a Paleozoic sea, we would probably find stalked crinoids existing at shallow depths comparable to those now populated by feather stars—100 feet or less. Why, then, are today's stalked crinoids found primarily at depths greater than about 300 feet—well below safe scuba limits?

One possible answer may lie in the significant difference between modern shallow seas and those of 500 to 225 million years ago, namely, the great abundance and diversity of bony fishes today. Since the Cretaceous Period, about 100 million years ago, bony fishes have undergone an incredible burst

of evolutionary development. While fishes possess a great variety of feeding habits, a large number are predatory. Some tropical reef fishes have become specialists in feeding on reef-dwelling invertebrates that have hard skeletons, such as corals and mollusks, and possibly sea lilies and feather stars.

We believe that stalked crinoids would be much more vulnerable to predation by such fishes if they lived in the extreme shallows where these fishes are most abundant. Even though they may possess toxic properties, have the ability to escape, and can hide during daylight hours, the shallow-water feather stars suffer to some degree from fish predation. Interestingly, there are no known records of shallow-water stalked crinoid fossils from rocks younger than 100 million years. Thus it appears that the restriction of stalked crinoids to deeper waters followed the great burst in fish evolution of the Cretaceous Period.

Four hundred and eighty-five species of feather stars have been identified, living in a wide variety of marine environments. Their mobility is thought to account for their present numbers.

D. Bradford Macurda, Jr.

David L. Meyer

Feather stars today outnumber the once predominant sea lilies. Because they are mobile, feather stars can perch wherever there is food. The specimens at right, found along the east coast of Malaysia, are clinging to plate coral. The one above was found at the Great Barrier Reef.

Is this relationship merely a coincidence or does it actually reflect the inability of stalked crinoids to cope with increasing fish predation in shallow waters? Like many questions about ancient life, this one will be difficult to answer. However, paleontologists in recent years have found that when the fossil record is examined with a clear understanding of living animals, new and unsuspected doors open on the life of animals of the past. □

Why Some Deer Are Safe From Wolves

by L. David Mech

Around a wolf pack's territory is a buffer zone, or DMZ, which is a good place to be if you are a deer

The greatest feeling of discovery I have had in twenty years of research came in 1975 when I placed a graduate student's maps of individual deer ranges over my own plots of wolf pack territories: almost all the deer studied lived along the very edges of wolf territories. Because most of my research has been descriptive, I can usually anticipate conclusions before the final data are in. Generally, images of study results that are at first murky become increasingly sharper as data accumulate. In the case of the deer and wolf maps, however, sheer curiosity had led me to superimpose the maps.

My students and I had been conducting studies of both the wolf and its major prey in the central Superior National Forest of northeastern Minnesota. After capturing deer in their winter yards, or concentration areas, we attached radio collars to them, just as we had done for years with wolves in the same area. The four yards where we trapped the deer were all situated along the edges of wolf pack territories. Each wolf territory covered some 48 to 120 square miles, while each deeryard encompassed only a few square miles. We did not think it especially unusual that the few yards where we found deer wintering were along the edges of wolf pack territories.

A male timber wolf has scent marked the tree stump at his flank. Wolves mark the buffer zones around their territory at about twice the rate as the area at the center.

John Ebeling Bruce Coleman

Until about 1972, deer overwintered in many areas throughout wolf pack territories. Beginning in 1966–67, however, a series of seven severe winters seriously imperiled the deer herd. A high wolf population added to the winter stresses on the deer, particularly in the increasing areas of mature forest—the poorest deer habitat. (As tree branches grow out of reach of deer and shade the undergrowth, the amount and quality of deer food decrease.) By 1974, the deer population of the eastern half of Superior National Forest had declined markedly, and a 1,200-square-mile region of the poorest habitat lost all of its overwintering deer.

Along the western edge of the deerless region, deer numbers had also dropped precipitously. Within easy reach of our field station, however, the four deeryards under study persisted, even though the number of their inhabitants had diminished.

Most of the deer we radio collared migrated long distances—some as much as twenty-five miles—from their yards to summering areas. Thus the individual summer ranges of these deer were scattered over an area covering several wolf pack territories. Each deer summer range occupied about 0.25 to 1.8 square miles.

When I laid the deer summer range maps over the plots of wolf pack territories, the results were difficult to believe. Of the sixteen deer summer ranges, thirteen lay along the edges of wolf pack territories! Two other deer lived much closer to edges than to centers, and one deer summered outside the area for which I had data on wolves.

I was elated at the surprising results. There was little chance that the findings were mere coincidence. Furthermore, I suddenly saw the significance of the fact that the four yards where our deer had overwintered all lay along wolf pack territory edges. Since those original findings, radio-tracking data from many more deer and studies of summer and winter deer distributions have all confirmed the early results: during the period of low deer density, most of the surviving deer inhabit wolf pack territory edges, both in summer and winter.

The question was why. Three possibilities came immediately to mind: (1) deer habitat may be better along wolf pack territory edges; (2) deer may find some advantage in occupying pack territory edges and thus may deliberately seek them out; and (3) deer living along territory edges may survive longer than those in centers.

The first possibility could be dismissed rather quickly. Deer habitat along wolf pack territory edges cannot usually be distinguished from that elsewhere in Superior National Forest. Throughout most wolf territory centers, there are large amounts of deer habitat as good as, or better than, that along the edges.

The second possibility assumes that deer can somehow detect wolf pack territory edges, that they find some advantage in living there, and that they mentally connect the advantage to the existence of the territory edge. Clearly there is an advantage to deer inhabiting the edges of wolf pack territories or there would not be higher deer densities along edges than in centers. But to propose that a deer can distinguish wolf pack territory edges, and that it can connect the edges with the advantage of living there, seems to be stretching the animal's abilities.

Enough evidence supports the third hypothesis to make the first

and second seem unnecessary. The third hypothesis assumes that when deer densities are high, deer live throughout wolf pack territories, but those that happen to live along territory edges have a better chance of surviving. Then, when deer decline, those inhabiting territory centers tend to be killed off first, leaving only some of the deer along the edges surviving.

Before the deer declined in Superior National Forest, they inhabited wolf pack territory centers, as well as the edges. Data also confirmed that as the deer declined, wolves primarily killed deer in their territory centers. In the Harris Lake pack territory, for example, only one of the twenty-seven kills I recorded for this pack from winter 1968–69 through 1971–72 was made in the territory edge. As deer continued to decline, however, the Harris Lake pack became so desperate that its members had to trespass far into other pack territories to make kills. At the same time, the pack began to kill deer in its territory edge. From winter 1972–73 through 1974–75 members of the Harris Lake pack killed almost half their deer along their territory edge. An analysis of the ages of deer inhabiting edges showed that they averaged 5.4 years old. Of a sample of 17,066 hunter-killed deer from northern Minnesota, only 3 percent were more than 5.5 years old, and the average age was 2.0 years old.

How can deer inhabiting wolf pack territory edges avoid attack and survive so long? I believe the answer involves a great reluctance by wolves to use their territory edges. An understanding of this reluctance requires a discussion about wolf pack territoriality.

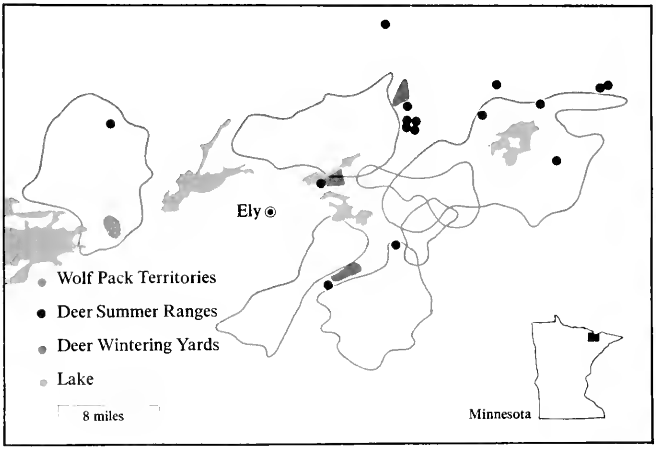
Each wolf pack territory is usually surrounded by five or six other territories. The edge of a territory includes a strip some one to two miles wide or wider, which may overlap that of neighboring packs. Just how adjacent packs use this strip, which has been referred to as a buffer zone, is not yet clear. Under most conditions, however, it is only in the buffer zone where a pack may encounter its neighbors.

When wolf packs meet, the inevitable result seems to be a serious fight, often ending in the death of one of the top-ranking pack members. Probably because of this, buffer zones apparently are not used very intensively by packs on either side. When a pack does enter a buffer zone, it scent marks the area at about twice the rate as in its territory center. This may indicate a certain insecurity in the contested area.

How infrequent use of buffer zones by wolf packs would foster survival of the deer inhabiting the strip is easy to see. Although the buffer zone is relatively narrow compared with the diameter of a pack territory, it is wide enough to support numerous deer. When a deer herd is at a high density in a wolf pack buffer zone, some of the deer eventually disperse into the wolf territory centers. Because maturing bucks disperse farther than does, higher proportions of bucks would presumably occupy territory centers, while most does and fawns would live in or near buffer zones. This hypothesis has not yet been tested, but work on the subject is under way.

What we do know is that adult bucks tend to be killed by wolves at

Peering at the photographer, a timber wolf is half-hidden by the grasses, brush, and young trees that characterize good deer habitat. A more mature forest would support less deer.



Rollie Ostermick

an earlier age than adult does. Of 142 wolf-killed deer we sampled, no bucks were over 9.5 years old, whereas seven does were from 10.5 to 14.5 years old. Because deer are polygamous, a single buck can service as many as twenty does. Thus, many bucks can be viewed as surplus members of a deer herd that could disperse from buffer zone reservoirs into territory cores. They could return to the buffer zones to service the does, inhabit the cores for the rest of the year, live there in relative safety during their prime years, and then succumb to wolf predation as they become older.

Meanwhile, according to the theory, successful does living in relative security in and near the buffer zones could continue to breed each year, thus helping to maintain the population. As deer numbers build up, small local herds of does and fawns may even colonize areas closer to territory centers. New wintering yards may develop and survive for many years. But when a population decline begins, deer in these yards, which are always under greater wolf predation pressure, would eventually be decimated, as happened in Superior National Forest.

The theory outlined above implies that locations of wolf pack territories must be stable for long periods. If they were not, some buffer zones would end up in pack territory centers and the deer in them might eventually be decimated when conditions become severe enough. No one has yet studied individual territory locations long enough to determine how long they are stable. Nevertheless, certain inferences can be made.

Several pieces of indirect evidence suggest that wolf pack territories generally are stably located for long periods. First, wolves may live for fifteen years or more, which would allow an individual and its mate to maintain their land tenure for a long period just within their own lifetimes. Then, since each territory is occupied by a pack, which consists of a family group, the potential is excellent for occupation of a territory by offspring for generations.

This potential for traditional use of a territory would be socially reinforced by the constant presence of surrounding territories. Except for adjustments of precise boundaries along the buffer zones, strong social pressure should keep each pack within its own territory. Wolves caught trespassing are killed or seriously injured.

Even when natural catastrophes befall a wolf population, the land-tenure system probably survives. For a wolf population to persist, each pack territory must be large enough to support not only the breeding pair but also several of its offspring. This means that even during a severe food shortage probably enough prey will persist to allow the alpha pair to survive and hold the territory.

I observed an extreme example of this principle in operation with the Harris Lake pack in Superior National Forest. These wolves occupied a territory of approximately 85 square miles, surrounded by at least five other territories. As the deer herd declined from 1968 to 1974, the Harris Lake pack decreased from nine members to two, a drop of almost 80 percent; still the two survivors—the alpha pair—continued to hold the territory. In fact, the Harris Lake pack territory has persisted for at least ten years.

Thus, the social and spatial organization of the wolf population, in northeastern Minnesota at least, make it probable that locations of wolf pack territories are stable over periods of decades, long enough to be compatible with the buffer zone theory.

Similarly, the characteristics of the deer herd in the area imply that locations of deer ranges are also stable over long periods. Deer can live as long as twenty years; we have records of individuals more than thirteen years old in our study area. Although we still do not know as much as necessary about the deer's social and spatial organization, the data so far support the buffer zone theory. Individual deer apparently use the same winter and summer ranges year after year. Furthermore, each year the new fawns accompany their does to the winter ranges and back again to their summer range. Certain evidence, so far indirect, indicates that even when these fawns mature, they settle in or near their mother's summer range and return each year to the same winter yard. No doubt these traits explain findings from Michigan that almost all deer yard-

Brandenburg

Searching for forage, three deer, above, follow well-used trails through the snow cover in Superior National Forest. They have yarded for the winter in a buffer zone between the territories of adjoining wolf packs. Because this zone is infrequently visited by the wolves of either pack, these deer will live longer than those overwintering in the midst of pack territories. Also, as the deer tend to use the same winter yards and summer ranges year after year, those in buffer zones produce more surviving offspring. Two wolves, right, feed on a deer that they have pulled down, while a lone raven waits for any remaining scraps.

ing in each wintering area migrate in spring to summer ranges in the same general direction. Deer in Superior National Forest do the same thing.

How deeryards tend to persist, and how those in wolf pack buffer zones persist longest, is then apparent. Furthermore, because deer surviving the longest would tend to produce more offspring, the tendency would always be toward the largest deeryards building up in the buffer zones. The same principle would also hold for deer that inhabit buffer zones in summer. The net result would be a concentration of deer that both summered and wintered in buffer zones.

This deduction poses the question of why, in wolf country, any deer at all live anywhere other than in wolf pack buffer zones. The answer no doubt lies in the fact that all organisms must compete for survival. Thus, as long as there are more deer in an area than can live only in buffer zones, some individuals will be forced to live elsewhere. These could be decrepit or old individuals no longer able to compete with their more vigorous descendants. They could even be adult males forced away by matriarchal groups of protective does to insure optimal resources for themselves and fawns.

Although the above is only speculation, it gains some support from two pieces of information. First, most of the adult deer killed by wolves are older than the average in the population. Of the 142 wolf-killed deer sampled, 48 percent were at least five years old. Second, some deer biologists believe that bucks tend to live along the outer edges of winter yards. As discussed earlier, bucks are polygamous and therefore more expendable to the herd. Thus it seems likely that competitive behavior against bucks might have evolved in does. This question still needs considerable study, however.

Nevertheless, the possibility that less productive or less important members of the deer herd might be forced to less secure areas finds precedent in other prey of the wolf. The musk ox is an excellent example. The cows and calves—and a few breeding bulls—live in herds that form a defensive circle against wolves. The young and old bulls, however, live away from the safety of the herd, and are thus more vulnerable to predation. Similarly in caribou, most bulls assemble in small groups or live as single stragglers away from the main herds of cows and calves.

Clearly, many more data need to be collected about the spatial aspects of relations between wolves and their prey in order to better understand the buffer zone as a prey reservoir. Even more necessary is independent testing of the theory, with wolves or with any other carnivore. Such testing can only be done, however, in predator–prey populations with a minimum of interference by humans. Although the wolf territorial system seems highly buffered against natural disasters, the artificial killings of entire packs could disrupt territorial traditions. Surrounding packs may then annex part or all of the vaçant territory and obliterate the traditional buffer zones.

That is exactly what happened in the only other example I have found of a buffer zone acting as a prey reservoir for any species other than wolves. Ironically enough, the predators were humans. From 1780 to 1850 a buffer zone existed between the Chippewa and Sioux tribes in Minnesota. Members of both tribes ventured into the zone, but neither tribe spent much time there because of the threat of an attack by the other. According to anthropologist Harold Hickerson, this buffer zone became the main area where white-tailed deer survived. However, European traders eventually effected a truce between the two tribes. The result? The deer were soon exterminated from the buffer zone. □

A pack traverses a part of its territory, probably on the lookout for prey. Each pack is a family group, and succeeding generations often occupy the same territory, in some cases for decades.

Rolf O. Peterson

Portraits pages 78 through 82 courtesy of the Robert and Frances Flaherty Study Center

Avaleeniatuk

On Koodjuk's Trail

Robert Flaherty's photographs evoke the past for Cape Dorset Eskimo

by Dorothy Harley Eber

The search for relatives of those Eskimo (Inuit) who posed for my father's camera some sixty years ago began, belatedly, in 1974. The chances of success, of course, were slim.

However, a fascinating encounter in Ottawa in the fall of 1974 lent hope to the project. I had met Annie Niviuxie—down from her home in Great Whale—and given her the Flaherty pictures to examine. Annie's friend Mina and Tookasie, a young Inuit interpreter, were with us. Annie singled out one of the portraits and told us it was her grandfather—none other than the great Nanook!

The next step was to send sets of the photographs up to settlement managers in the far north, with the request that the pictures be circulated among the older generation Inuit. This "long distance" approach proved disappointing.

In 1977 I looked up Dorothy Eber in Montreal. Eber, who had heard stories about that "picture taker" Robert Flaherty from her friend Peter Pitseolak, offered to take the photographs with her on her next trip north.

"On Koodjuk's Trail" tells the rest.

MONICA FLAHERTY
The Flaherty Study Center
Brattleboro, Vermont

The snow houses are gone forever on the south Baffin coast, but in Eteenik, site of a once great Eskimo winter camp, a wooden shack still stands where an Eskimo working for the Hudson's Bay Company used to gather in fox furs and hand out trade goods. In the winter of 1913–14 this was a makeshift darkroom where Robert Flaherty, the pioneer documentary filmmaker, developed his photographs with help from Allego, remembered today on the Hudson Straits as an illustrious woman shaman. (The shack, report has it, was about the size of a "large box," and the women used the outside for "nailing up sealskins to dry.")

Ulayu Pingwartok, an elderly widow who died shortly after our conversation and whose drawings of tattoed women in old-time Eskimo clothing appeared regularly in the annual editions of the well-known Cape Dorset prints, was in Eteenik when Flaherty, whom the Inuit called Koodjuk ("swan") because his flesh was white, made his long ago visit. "I was just a wee girl, just old enough to talk. Allego was helping Koodjuk with the developing, and we were told that when they were developing there was not supposed to be light coming into the house. We used to peek through the door. We would open the door and run away—and then open it again and run again. After I was grown up Allego used to tell me, 'When you were a wee girl you used to be naughty looking into Koodjuk's house when we were developing.' " Other old people reported that Koodjuk also taught Allego and her pretty sister Emenik another mysterious art—writing. "It was winter and they couldn't write on paper because the weather was too cold," Mumamee Shaa explained. "They used to look for stones and blow on them. If their breaths made a white surface, they would write with a stick. They used to wear their mitts. That's how they used to write."

For both Flaherty and Allego, fame was around the corner. In six years time Flaherty would shoot his masterpiece, *Nanook of the North*. As for Allego, soon she would begin to live with an older man from a northern region. When, years later, she came back to the Baffin coast she would have tattoos—"very beautiful ones," an old man remembers—a shaman's powers, and the fire and the seaweed as helping spirits. In time she would marry Alariak, another shaman, and they would become famous south Baffin shamans.

I have never visited Eteenik, but recently, in the warm kitchens of prefab houses in Cape Dorset and Lake Harbour where the south Baffin Eskimo now live, I spent hours hearing of Koodjuk's activities in the camps along the coast and learning something of the lives of the people who posed for him.

Copies of these photographs—mostly remarkably beautiful portraits—had been sent to me by Flaherty's daughter Monica Flaherty when she heard I would be returning to Cape Dorset to continue gathering oral histories from the community's graphic artists. The negatives had been stored at the Robert and Frances Flaherty Study Center in Brattleboro, Vermont, but only Flaherty, who died in 1951, had known the identity of the sitters. I felt that with help from senior citizens—those extraordinary survivors of tumultuous change—and young interpreters, it would be possible to put names to at least some of the handsome strangers.

As it turned out, it quickly became known that the pictures were in town and when my interpreter and I pulled up at a doorstep on a Skidoo, we were always warmly invited to come in—and bring our pictures with us. Seated at kitchen tables we would shuffle the photographs like packs of cards, turning up relatives and personalities of the south Baffin coast and prompting many reflections. "You certainly have good old pictures," declared the widow Ulayu, "mighty men." "They look so sure of themselves," mused Annie Manning, at 25 one of

the first Eskimo teachers. "They lived in their own culture."

Television often flickered in the background as we talked. In one house the children watched the Shanghai Ballet and tried to imitate the dancers' steps. In 1971 an elderly Cape Dorset resident visiting Montreal had debated whether the television in her hotel room was operated by three miniature men working in the back of the set. Now the Canadian Broadcasting Corporation permeates much of the north and no one wonders how the pictures get there. At the time of my first visit to Cape Dorset in 1968, three camps still operated in the area and one camp group still kept dogs. But the erosion of the traditional camp system, which in the eastern Arctic began with the coming of the government and teachers in the nineteen fifties, is now complete. All over the Canadian Arctic the Inuit debate the pros and cons of settlement life: in the wake of change have come alcoholism, unemployment, and disorientation. When Flaherty first arrived with his camera in 1913, the forces of change were in their infancy: Christianity and reading and syllabic writing introduced by the missionaries were just beginning to sweep the coast.

Flaherty's ostensible business on the coast that winter was prospecting, but freeze-up prevented his ship, the *Laddie*, from entering Hudson Bay and delayed his attempt to map and prospect on the Belcher Islands. He wintered over at Amadjuak camp on the south Baffin coast. Peter Anumniuq, whose father-in-law, Noogooshoweetok, helped Flaherty with his dog team, says, "Koodjuk used to be taken to all the camps to see what people were doing because he wanted to take pictures." The pictures Flaherty wanted to take were moving pictures. He had with him his first movie camera and some know-how picked up from a three-week filmmaking course. An appealing account of his Amadjuak filming attempts is part of his book *My Eskimo Friends* (Doubleday, 1924): "We did not want for co-operation. The women vied to be starred. Igloo-building, conjuring, dances, sledging and seal-hunting were run off. . . ." Unfortunately, this historic footage has disappeared. But the still photographs, perhaps taken as casting aids, remain—an ancestral record for a posterity now living, as the old people say, "the new way."

Our looking-at-pictures sessions usually began with expressions of admiration for the wonderfully tailored skin clothing worn by the people in the pictures. "It's really embarrassing to wear the other kind of clothes when you're used to caribou-skin clothing," one old woman remarked. "We who really lived in the old way will never forget how to make skin clothing because we wore those clothes ourselves." As we looked through the pack there would be excited cries of recognition: "That's Mai—she was young and beautiful once in her life, too." "It looks like Elissipee—I'm so glad to see her. When I was born, she held my mother." Among the twenty-five or so families I visited, I met many people who recognized mothers, fathers, grandparents, and other relatives in the pictures. And I met perhaps six who, like Ulayu, had been children in the camps Flaherty visited. "I know that man," said the Lake Harbour hunter Ekiduak; "as a

little boy I even slept in his igloo." And my talented friend the graphic artist Pitseolak Ashoona still has a memento of Koodjuk's visits: a scar on the kneecap. "I was bitten by Koodjuk's dog. I stepped on its toes; that's why it bit me." Koodjuk's camera also made an impression: "It was small, but I knew it was complicated. It had to be taken up to the eye. Elee was getting ready to go on a dog team and a picture was taken of Elee."

The informant who knew Koodjuk best was Simeonie Kopapik, now a catechist in Cape Dorset, who was a little boy, "just beginning to play outside on my own," when Flaherty and his crew of three made Amadjuak their base and built wooden houses there. "Koodjuk used to talk to me a lot and really loved me," Simeonie remembers. "Once he showed me a little qukeyottaoyuk, a 'crossbow,' and asked me to shoot it. I did and Koodjuk was so pleased he clapped his hands and gave me the little qukeyottaoyuk."

Simeonie gave an eyewitness account of how Flaherty went about taking his portraits. "They had to take them inside, in Flaherty's house. I don't recall them having flashes with the camera. They used kerosene lanterns, and I remember three lanterns being placed in special places on the wall. I remember a camera with a cloth that had to go over the head. Maybe that was because they had to prevent any light coming to the photographer's vision. It took a long time before the photographer could actually take a picture. They couldn't take a picture of a person as soon as he sat down. They had to relax him first. The man sitting on the chair had to be very relaxed . . . if he was liable to move at all they couldn't take his picture. That's what I remember."

Flaherty apparently circulated original prints around the camps as Simeonie's mother, Mai, had several in her possession. Some were the same as photographs I had with me, and Simeonie was able to pick out from the pack a picture of his mother, several pictures of his sister, and a "probable" picture of himself. (Among the portraits are many charming pictures of children: although the subjects may very well be living, these proved the hardest to identify.)

Simeonie also recalled the movie-making operations. "At that time they had moving pictures without sounds. Koodjuk had a white man in charge of taking moving pictures. I don't remember the type of camera, but I can remember it was a big camera on a tripod." A drawing by an Inuit artist, which may have been done during the 1913–14 winter and now in the possession of the Royal Ontario Museum in Toronto, turns the tables on Flaherty and shows him and others filming. While in Amadjuak, Flaherty collected drawings by Noogooshoweetok ("everlasting")—one of his helpers—and later published them in a folio (the artist's name was misspelled and appears as Enooesweetok), but the drawing of the filming operation and perhaps one or two others in the Royal Ontario Museum collection appear likely to be by a different hand.

It was Noogooshoweetok, too, Simeonie remembers, who with others captured a caribou and brought it back to camp for Koodjuk's filming. "In those days we

Allego

Kanyuk

lived in different camps but we got together at Christmas," recalls Simeonie. "But that year a man was sent to give a message to Koodjuk and he didn't even come to shore. The message was left on the beach. The letter was saying that the [Hudson's Bay] Company didn't want any more people in Lake Harbour for celebrating. They were jealous; they thought Koodjuk might take their Eskimo workers." As a result Koodjuk was host at Christmastime. "We celebrated in Koodjuk's house. We had a feast and there were games. There were the four white men and I don't know how many Inuit . . . quite a number." And Simeonie also remembers that "there were three girls—Allego, Kanyuk, and Kingnatchia ('beautiful nose')—who were friends of these men."

By chance, I had discovered a picture of Kanyuk and a picture most probably of Allego, Koodjuk's darkroom assistant, at an earlier date. In 1972 I began working intensively with the late Peter Pitseolak (he died in 1973), a remarkable Eskimo who in the early nineteen forties began photographing the vanishing life style "to show how for the future." As a boy of eleven, he had also met Flaherty. Pitseolak's daughter Kooyoo says, "He probably got the idea he wanted to have a camera and do the same thing." In time he did. Many people who posed for Flaherty also posed for Peter Pitseolak.

The Notman Archives of McGill University's McCord Museum, where Peter Pitseolak's negatives are stored, provided me with three Flaherty photographs that had found their way into the files. Could Peter Pitseolak identify them? Peter Pitseolak quickly named them: Allego, Kanyuk, and Anumniuq, who caught three blue whales on the whaler *Active* and was a pilot for the white men. ("That's my father just as he was in life," the old woman Anirnik later remarked.)

Later, after Peter Pitseolak's death, when I showed the Allego picture in Cape Dorset, an elderly viewer asked, "But where are the marks?" Allego's marks—her facial tattoos—had been memorable; perhaps the picture was of Seereseeak, a sister who died young. But then he remembered that Allego's marks were those of another region; she had obtained them after she left south Baffin, while she was away becoming a shaman.

This probable picture of Allego, a smooth-faced young woman without tattoos, always generated intense interest; even younger people seemed to know her by reputation. As an example of female pulchritude, however, Allego clearly lost out to Kanyuk. Lovely Kanyuk is long since dead, but in Cape Dorset today live a sister, a half-brother, and her son, the Reverend Timothy Kalai, now the community's Anglican clergyman. One evening I took the photographs to show to the Kalai family. Timothy Kalai had never known his mother or seen her photograph. While I was in Cape Dorset, his daughter Rebecca Kanyuk was married in the Anglican church in a long white dress. Plans are under way to send an appropriate wedding present—a portrait of her hauntingly beautiful grandmother.

Flaherty took portraits of several members of Kanyuk's family. One was of her father, Ishuhangitok, who was described as a very traditional man. "Even when they started to have short hair, he still wore long hair. And the men's parka used to have a tail—he had a tail on his parka." Also in the pack was a picture of a little half-sister who, as is sometimes the case in Eskimo families, was also called Kanyuk and was known as "the little Kanyuk." We also found a picture of Takolik, the boy who became her husband. On the shoulder of his sealskin furs is a dark stripe. I learned that such an inset "shows a boy has become a hunter and caught his first seal." Girls got the amaut (hood that can hold a baby) at the time of first menstruation. Takolik and the little Kanyuk are alive today and living in remote Spence Bay.

Sometimes a photograph would cause the unreeling of a life's events, happenings all in the future when Flaherty clicked the shutter. Among the pictures were those of Flaherty's Eskimo guides and helpers: Attaché who, according to the Lake Harbour hunter Ekidluak, supplied the dog team Koodjuk used ("Attaché's poor dogs were very skinny, but it turned out these seaweed fleas were very fast even though they looked so poor," Peter Pitseolak reported); Simonie, the second man on the dog team; Noogooshoweetok who apparently starred in the movies; and Avaleeniatuk. I noticed that people looked long and hard at the picture of Avaleeniatuk and sometimes asked for a copy. One evening in Cape Dorset, Pauta and his wife, Pitalosie, whom I had come to know rather well when she was hospitalized, told me why. With Pitalosie interpreting, Pauta explained that about ten years after Flaherty was in Amadjuak, Avaleeniatuk and his wife and three children were with a group of hunters on a difficult part of the coast just before freeze-up. When Avaleeniatuk's wife became ill, his hunting companions went on ahead. Avaleeniatuk and his children starved. "Tunillee lived in a camp in the area. He was a very helpful man

Dorothy Harley Eber

Rebecca (Kanyuk's granddau...

An Inuit artist's drawing of Flaherty's ship, the Laddie, *and a baseball game organized on New Year's Day 1914.*

although some might make a criticism. He was on a dog team going up by the land, not by the ice, to Cape Dorset and the Hudson's Bay Company post and he found the bodies of the children in a little tent. Maybe the mother died and Avaleeniatuk buried her and went for help. He was never found. In those days they used the sealskin tents, and Tunillee found the bodies all covered up in one place—three of them. There was a little hill behind and there were tracks. Everyday the children were walking up the hill to look for their Mummy and Daddy. Though it is a long time now since they died, I feel sorry for them even today."

The detective work involved in identifying the pictures was endlessly fascinating, provoking as it did these evocative stories out of the past. Among the photographs Monica Flaherty had sent were a considerable number taken in Arctic Quebec. Separating these from the Baffin coast pictures was never a problem: the clothing from the different regions made the pictures readily identifiable. I discovered, too, that Eskimo attribute specific physical characteristics to different regions: "Those high eyebrows come from Arctic Quebec."

There were some problems of course. Identification of the pictures would certainly have been easier five years earlier. How I missed Peter Pitseolak, his powerful mind and his knowledge of the coast. In general, if two people put the same name to a picture, I considered the identification adequate. But occasionally this was not sufficient. Family resemblances are strong and at times several viewers (not necessarily on the same occasion) identified a subject who, after I made an effort to obtain dates and additional information, turned out to have been a mere child at the time of Flaherty's visit. This was the situation with a picture that initially seemed to be of Peter Pitseolak's half-sister Eleeshushee. I had known Eleeshushee as an old lady, and the likeness did resemble her as she might have looked in her middle years. "Even the hands are the same," said one of the interpreters. And they were —even to the rings on the fingers. But regretfully I discarded this identification. Eleeshushee was born in 1896 and would have been only seventeen at the time of Flaherty's visit. The picture remained a tantalizing puzzle. A few days before I left Cape Dorset, however, I showed the pictures to a large group gathered in the house of the well-known carver Oshoweetok Aipeelee and his wife, Nipisha, a much younger sister of the beautiful Kanyuk. With us was Alma Houston who, in the fifties and early sixties, had encouraged most of the people present to participate in the print-making project and to send their carvings south. The old artist Pudlo took one look at the picture and confidently identified it as Eleeshushee's mother.

Another photograph that resisted identification was of a marvelously handsome woman who seemed an exemplar of her race and time. I felt she had such character and presence that she must be someone of importance. But in all the houses in Cape Dorset, I drew a blank. My work lay in Cape Dorset, but I knew that the Eskimo people in the smaller community of Lake Harbour—the point where the white man had first established himself on south Baffin—would also be interested and able to help. I decided that on my way home through Frobisher Bay, kickoff point for the Baffin settlements, I would try to make a side trip. It was mid-November and weather conditions were poor; in the end I was able only to spend an afternoon there, flying in and out on the same plane. But my Frobisher Bay hosts were Bob Hanson and his wife, Ann, great-granddaughter of Anumniuq, the subject of one of Flaherty's finest portraits. (As we looked at the pictures, Ann's four young daughters pretended to photograph us with their Brownie cameras.) Ann arranged for a young woman named Pitseolak Akavak to meet

the plane, and using her Skidoo, we spent a busy afternoon paying calls. Always I showed the mystery picture. Our last visit was to Ekidluak, who had met Flaherty as a child. This time when I showed the picture the response was immediate. "Guseevie!" he said. He and his wife, Martha, had known Guseevie well; she had indeed been a dramatic and notable personality on the coast. She was one of the hunter Elee's several wives, she played the music box, and led the dances in what is known as the "second religious time." "At that time [about 1908], when the people were changing from their old religion to the new," explained an informant, "they were very mixed up and believed if they didn't dance when asked by the leaders, they couldn't be saved." Guseevie is still talked about today. A bonus was Ekidluak's identification of her handsome son, Suka ("sugar").

Flaherty's cameras were not the first on the coast. The "first" in Eskimo memory appears to have been a movie camera that belonged to Wallykudluk, "short" Wally, a whaler on the whaling ship *Active*. It was seen by Kingwatsiak, a hunter on the *Active* at the turn of the century. Sakiassie Ragee of Cape Dorset, who likes to take pictures himself, reports, "Kingwatsiak said that Wally loved that camera more than his life." A. L. Fleming, a missionary in the area, also chinked an igloo to exclude all light and worked with glass negatives. But these were incidental activities. Flaherty is remembered today through the oral tradition as "the picture taker."

Periodically, Eskimo in the region have wondered what happened to the pictures Flaherty took. There was general lamentation when I explained that the reels of film he shot cannot now be accounted for. Looking at the still photographs, Simeonie Kopapik remarked sadly, "If these were in moving pictures, they would be very real Inuit." Our young interpreters echoed his words, "They would be very authentic."

It appears that Flaherty's first footage was dogged by vicissitudes. Some, as he reports in *My Eskimo Friends*, was lost through the ice; more was probably burned in an accident in his studio. But it is believed that some appeared in a print, known as the Harvard print, that survived the fire. Monica Flaherty says, "He later used this print to persuade Revillon Frères to finance the making of *Nanook of the North*." Where is it now? In all probability, Monica Flaherty believes, it has been thrown away. There is a slight possibility it might still exist among the effects of the Revillon company or of Pathé (USA), the distributor of *Nanook of the North*. But one thing is certain: should somebody manage to turn up the missing film, he will be a hero on Baffin Island.

I returned from Baffin Island with requests for pictures of grandfathers, great-grandmothers, godparents, and uncles and aunts. And there were some special orders. After spending time perusing the pack, one young boy asked very politely if, from my vantage point in Montreal, I could obtain a picture of hockey great Guy Lafleur.

With the cooperation of Monica Flaherty and the Robert and Frances Flaherty Study Center, four enlargements will be sent to decorate the walls of the Cape Dorset school, which many descendants of the people Flaherty photographed now attend. But which four pictures to send? The decision is difficult, but I think my personal choice might fall on lovely Kanyuk; Allego, the darkroom assistant; Anumniuq, the great hunter; and Avaleeniatuk, who starved to death. Those who lived the old way say the old times were happy times, but they also remember the ever present danger of shortage and death. □

This pencil drawing of Flaherty and his crew filming igloo-building shows the camera in three positions.

Royal Ontario Museum

An Annual Aphid Cycle

Photographs by Dwight R. Kuhn

Parthenogenesis, viviparity, oviparity, polymorphism—all are part of the survival strategy of a tiny insect often thought of as a louse

In popular usage, aphids are often called plant lice. These tiny insects can virtually blanket the leaves of a plant, drawing nourishment by sucking the juices from their host and transmitting viral diseases in the process. A gardener or farmer, knowing what is going on, can be excused for the analogy with lice. Many aphids are serious agricultural pests, and while pest may be an anthropocentric designation, there are more than 3,000 species of aphids around the world, feeding on vegetation and causing varying amounts of damage to the affected plants. When they compete with man for the nutrition in a cultivated crop or affect his aesthetic pleasures, aphids become pests.

Aphids should excite the curiosity of anyone interested in evolutionary biology because their modes of reproduction can be so complex that a mind for chess is almost a requisite for following the changes from generation to generation. Some are more complicated than others, but all are fine examples of circuitous, yet ingenious, adaptability.

The aphids pictured in this article belong to the genus *Macrosiphum*. In that part of their range in the state of Maine where these photographs were taken, they alternate host plants at different times of the year. In spring, they feed on the young leaves and shoots of woody plants. As the leaves of the woody plants mature and become less succulent, the aphids migrate to herbaceous plants (this species prefers goldenrod) on which they feed throughout the summer. In the autumn, they return to their original woody hosts. Because aphids are short-lived, the utilization of different plant hosts in a variety of habitats is beyond the abilities of an individual. Consequently, these moves are made by different generations, and various methods of reproduction allow the aphids to make such feeding shifts.

The alternation of plant hosts within a yearly cycle involves a striking spectrum of reproductive phenomena that encompasses bisexuality and parthenogenesis (virgin birth) in combination with oviparity (laying eggs that hatch outside the body) and viviparity (giving birth to living young). Interwoven with these disparate means of producing young is a high degree of polymorphism between, and even within, generations. For example, the degree of development of some mouthparts changes over generations; within a generation, some females may have wings and others not. All of this, remember, in the same species.

The annual cycle of an alternate host aphid may be said to begin with eggs that have overwintered. Come spring, they hatch and give rise to wingless, parthenogenetic, viviparous females. This all-female population reproduces, by parthenogenetic viviparity, a new generation of similar kind. But in this second generation, a few females develop wings. This goes on for several generations, with the proportion of winged females increasing. These females capable of flight are the ones who migrate from the primary host to the alternate, secondary host, a behavior that occurs mainly in the summer. Those winged females that find a suitable secondary host settle on it and reproduce in the same fashion as females on the primary host did. With the advent of autumn and decreasing day length, the progeny of both winged and wingless forms give rise to a generation of bisexual males and females. After the males and the oviparous females mate, the latter lay the eggs that overwinter on the primary host and hatch out an all-female, parthenogenetic generation the next spring.

Another way of identifying the cast is to designate the different sequential types of individual aphids, something aphidologists have done. The *fundatrices* are the wingless, viviparous, parthenogenetic females that hatch from the overwintered eggs. Their sense organs, legs, and antennae are not as well developed as those of succeeding generations. This relative underdevelopment of body parts may be related to an increased reproductive capacity. The offspring of fundatrices are *fundatrigeniae*, which continue to live on the primary host. *Migrantes*, which usually develop in the second, third, or later generations, are winged, parthenogenetic, viviparous females. They develop on the primary host and subsequently fly to the secondary host. The *alienicolae* are parthenogenetic, viviparous females that mostly develop on the secondary host. These aphids can differ greatly from the fundatrices and migrantes in their morphology. Many generations of both winged and wingless forms are produced. A few generations down the line from the alienicolae, the parthenogenetic, viviparous females are called *sexuparae*. The winged forms are the ones that migrate back to the primary host at the end of summer and give rise to the *sexuales*. The

The larva of a flowerfly swallows a Macrosiphum *aphid.*

Photographs through Verda International Photos

The cast-off skins of molting aphids litter the surface of a leaf, top and center. Most generations of alternate-host aphids are all-female. They are parthenogenetic and give birth, bottom, to living young. The number of offspring, right, can vary greatly from generation to generation.

sexuales usually appear only once in the life cycle and consist of sexually reproducing males and females. The sexual, oviparous females are wingless and differ from earlier generations of viviparous females by having thickened tibiae of the hind legs and a greater body length. The males can be either winged or wingless and intermediate forms also occur. (Different types of specialization occur among male and female sexuales of different genera.) After eggs have been laid, the cycle ends for the year.

The fecundity of the different types of individuals and sequential generations varies widely. The fundatrices of *Sappaphis crataegifoliae*, a species in which fecundity was measured, produced an average of 71 live young. The average for the fundatrigeniae was 121; later generations were less prolific. Migrantes had an average of 18 young, the alienicolae 65, sexuparae 7, and the sexuales an average of 6 eggs.

If most of these progeny survived, they would soon outstrip the plant resources available to them. But fungi, parasitic wasps, ladybird beetles, and the larvae of some flies and lacewings destroy aphids in large numbers. Many aphids are also washed away by rains.

Whatever rough balance is involved in the population dynamics of aphids could be drastically upset by a major alteration of the vegetation type in an area. Such alteration is typical of agriculture. Those aphid species that find a crop fit for the role of primary or secondary host will mushroom in accordance with the increased food supply—and become pests.

Fred Hartmann

by Stephen K-M. Tim

A Modern Herbal

MEDICINES FROM THE EARTH, edited by William A.R. Thomson. *McGraw-Hill Book Company, $29.95; 209 pp., illus.*

It is of significance that of the ingredients in medications prescribed for various ailments, almost 40 percent have a plant origin, whereas only about 6 percent can be ascribed to animals. A difference in metabolism between the two groups of organisms has brought this about. As opposed to animals, plants lack an excretory system; consequently, a store of chemical compounds accumulates in the cells and tissues. Throughout the ages, some of these substances, ingested incidentally as part of the use of plants for food, were found to affect humans: some were poisonous; others were curative.

Ancient Asian and medieval European herbals are still consulted for their folk medicine. In more recent times, anthropologists and pharmacologists have joined forces with botanists in the field of ethnobotanical research among aboriginal peoples to tap the fund of medicinal plant lore that has come down through the ages.

Now a medical doctor has brought botany and medicine together, combining the expertise of specialists in ethnobotany, pharmacology, phytotherapy, and other, related disciplines in a book invitingly entitled *Medicines from the Earth: A Guide to Healing Plants*. The editor, William A.R. Thomson, is no newcomer to medical journalism. The author of a number of medical books, including one on plant medicines, *Herbs That Heal*, Thomson was the medical correspondent of the *Times* (London) from 1956 to 1971 and is at present medical consultant to the *Daily Telegraph*.

This book is essentially a nontechnical account of herbal medicine, but it caters equally well to the serious adherent of this study and the interested reader wishing to become informed. Scientific jargon is kept to a minimum, but where it

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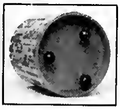

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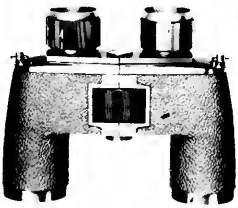

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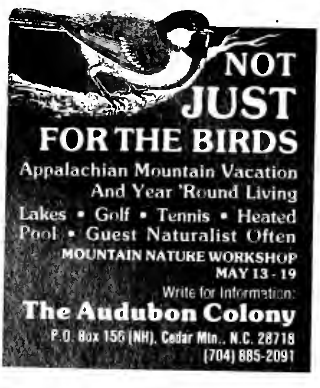

is used, it is explained clearly, thus making a glossary unnecessary.

Richard E. Schultes of Harvard University, a distinguished researcher in the field of hallucinogens and related subjects, covers the botanical and historical areas of plant-derived medicines in concise and inviting language. I found it strange that his fascinating chapter on the "Heritage of Folk Medicine" should come two-thirds of the way through the book; it should, in my opinion, be set near or at the beginning where history can provide a solid background for the information to follow. But I must admit that, after poring over three comprehensive lists of plants and/or ailments, the chapter offered a welcome interlude. Schultes shows again and again how a diverse range of plants documented in early herbals have stood the test of time—and modern chemical analysis—and been shown effective in healing.

One comes away with renewed hope for the future, at least so far as human health is concerned. But if one considers that vast continents, such as Africa, remain comparatively little investigated for their heritage of folk medicine, and that only about 10 percent of the organic constituents of the flowering plants, numbering some 500,000 species, are known, then indeed, inroads on the herbal iceberg have scarcely begun.

Much of the rest of the book is devoted to a study of 247 plants, all but 10 of which are flowering plants. Not until the section following the introduction of these particular plants are reasons given for their selection. Among others, these are plants of "proven effectiveness"; poisonous plants are excluded "except where no substitute could be found." For the five sections concerned, directly or indirectly, with these plants, Urte Knefeli, a specialist in phytotherapy, is the main contributor. His chapters provide three separate reference lists by which the reader can match herb with illness and vice versa. Preparation and dosages are also given. Knefeli's chapter on "Healing Substances and Their Effectiveness" deals with the specific parts of the plant to be used. Picture references, pinpointing these particular parts, are helpful additions. We are also told in

which season the herbs should be collected to take advantage of the optimal amount of active principle being present. In his introduction to this section, Thomson emphasizes that even the time of day can be a critical factor. For the more serious student of plant medicines, the active principles are outlined together with their effect on the body.

The three separate sections by Knefeli make interrelated information somewhat disjointed and confusing. Perhaps some of the information could have been amalgamated, reducing the need to jump from one list to the other. However, quick access to these three sections is facilitated by their being printed on attractive dull-finished green paper, and one soon learns to distinguish sections by their color and position along the "open" edge of the book.

Complementing Knefeli's lists is phytotherapist Bruno Vonarburg's coverage of the "Basic Techniques of Herbal Preparations." General directions for the collecting and drying of plants are given, and further processing, including the making of decoctions, infusions, ointments, and powders, is also outlined. The reader is cautioned about the danger of misidentifying plants, especially where poisonous species can be confused with relatively harmless ones.

The chapter by Eugen Bossard, druggist, botanist, and pharmacological journalist, entitled "Lexicon of the Healing Plants" characterizes the 247 plants, which are arranged alphabetically according


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Vocals — Helen Forrest

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All Of Me
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Stardust
It's Been So Long
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You Go To My Head
Shady Lady Bird

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And His Orchestra 1939-40
Vocals — Helen O'Connell, Bob Eberly

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Fools Rush In
Carolina In The Morning
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Nearness Of You
Shoot The Meatballs To Me Dominick Boy
You, You Darlin
Blueberry Hil
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Flight Of The Jitterbug

SPOTLIGHT IV — IV
CARMEN CAVALLARO
And His Orchestra 1946

My Sentimental Heart
Zing Went The Strings Of My Heart
I Didn't Know What Time It Was
I'll Follow My Secret Heart
It's Delovely
On The Waterfall
I've Got You Under My Skin
Souvenir
Rose Room
Lover
I Want To Be Happy
By The Waters Of The Minnetonka
Carefree
Sweet Lorraine
To A Wild Rose
Kiss Me Again
Just One Of Those Things
My Sentimental Heart

SPOTLIGHT V — V
LES BROWN
And his Orchestra 1944-46
Vocals — Doris Day

Leap Frog
Invitation To The Blues
Just A Gigolo
Man With A Horn
I Can't Help It
Flip Lid
Lou's Blues
Lovers' Leap
Sentimental Journey
Ready To Go Steady
12:55 Express
A Kiss To Remember
I Can't Believe That You're In Love With Me
I'm Making Believe
I've Got My Love To Keep Me Warm
Paper Moon

SPOTLIGHT VI — VI
LARRY CLINTON
And His Orchestra 1937-38
Vocals — Bea Wain

Dipsy Doodle
Remember
Whistle While You Work
Sugrfoot Stomp
Sugarfoot Stomp
Let 'Er Go
Hollywood Pastime
Martha
Chris And His Gang
Glen Island Hop
You Go To My Head
Zig Zag
Saving Myself For You
I Want To Rock
Where In The World
Feeling Like A Dream
I Double Dare You

SPOTLIGHT VII — VII
STAN KENTON
And His Orchestra 1941

Opening Theme
Tempo De Joe
Night Life
Marvin's Mumble
I Haven't Got The Heart
Elegy
Love Turns Winter Into Spring
El Choclo
Salari
Trumpet Symphonette
A Little Jive Is Good For You
Prelude To Nothing
Old Black Joe
Flamingo
Take It From The Oven
Balboa Bash
Closing Theme

SPOTLIGHT VIII — VIII
GLEN GRAY And The Casa Loma Orchestra 1939-40
Vocals — Kenny Sargent

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Wrap Your Troubles In Dreams
Hindustan
Hour Of Parting
It's Funny To Everyone But Me
Sometimes I'm Happy
No Name Jive
Meet Me Tonight In Dreamland
What's The Matter With Me
Little Brown Jug
In The Mood
Tuxedo Junction
Day In Day Out
High Society
Sassin' The Boss

SPOTLIGHT IX — IX
CHARLIE SPIVAK
And His Orchestra 1943-46
Vocals — Irene Daye

Stardreams
Mean To Me
Serenade In Blue
I Used To Love You
Cuddle Up A Little Closer
Blue Lou
Laura
More Than You Know
Stardust
Accentuate The Positive
Solitude
Travelin' Light
Blue Champagne
Let's Go Home
It's The Same Old Dream
Saturday Night

SPOTLIGHT X — X
OZZIE NELSON
And His Orchestra 1940-42
Vocals — Ozzie Nelson, Harriet Hilliard

Jersey Bounce
Moonlight Cocktails
Everyone But Me
Idaho
Somebody Else Is Taking My Place
Sir Walter's Serenade Breathless
Central Avenue Shuffle
Tangerine
Autumn Nocturne
Broad Jump
I Don't Want To Set The World On Fire
Cuttin' Classes
Strictly Instrumental
Jersey Jive
Texas Jump

SPOTLIGHT XI — XI
CLAUDE THORNHILL
And His Orchestra 1947

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Robbins Nest
Cabin In The Sky
Dead I Do
Happy Stranger
Medley: Jealous/Swinging The Lane/Breezing Along The Breeze
Just About This Time Last Night
Donna Lee
Poor Little Rich Girl
Polka Dots And Moonbeams
I May Be Wrong
Adios
Sometimes I'm Happy
Puffin' And Takin'
Sunday Driving
Anthropology

SPOTLIGHT XII — XII
DICK JURGENS
And His Orchestra 1937-39
Vocals — Eddy Howard

Day Dreams Come True At Night
Whispers In The Dark
Me, Myself And I
Gone With The Wind
There's A Brand New Picture In My Picture Frame
This May Be The Night
A Sailboat In The Moonlight
Swamp Fire
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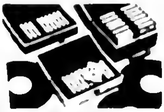
Will You Remember Tonight Tomorrow
In A Sentimental Mood
The Merry Go Round Broke Down
Harbor Lights
King Porter Stomp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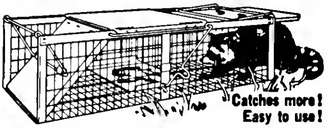

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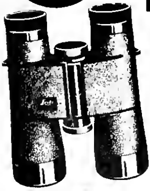

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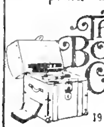

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to their scientific, or Latin, names and numbered in sequence. The usefulness of this numerical system is doubtful; it really does not make cross-references between the lists any more efficient. The individual plants are presented most attractively in wide columns down the pages, conspicuously headed by scientific and common names, family, origin, and present geographical distribution. A clear photograph or drawing of the plant or its inflorescence, in color, follows, usually before the text.

Nontechnical descriptions of all the plants are included, but some are easier to follow than others. There are a small number of instances where the text is not at all clear. For example, for *Ceanothus americanus,* the common names listed are New Jersey tea and redroot. However, the common names used at the beginning of the text are different from these, leaving one in doubt as to whether the plant cited is the one referred to. The sudden mention of New Jersey tea at the end of the description only complicates matters. Added to this is a discrepancy in the description of the leaf shape: the acute-tipped leaves of the drawing, correct for *Ceanothus americanus,* do not conform with the "egg-shaped [leaves], ending in a blunt point" cited in the text. Also, the flowers are not in spikes but panicles.

In at least four cases, the "byname" is used where "species" or "specific epithet" is intended. As regards questionable information on the provenance, or nativity, of *Aesculus hippocastanum,* the horse chestnut, it seems unlikely that its spread through Europe from the Balkan Peninsula would have taken place "across the Caucasus . . . ." A western route seems more feasible.

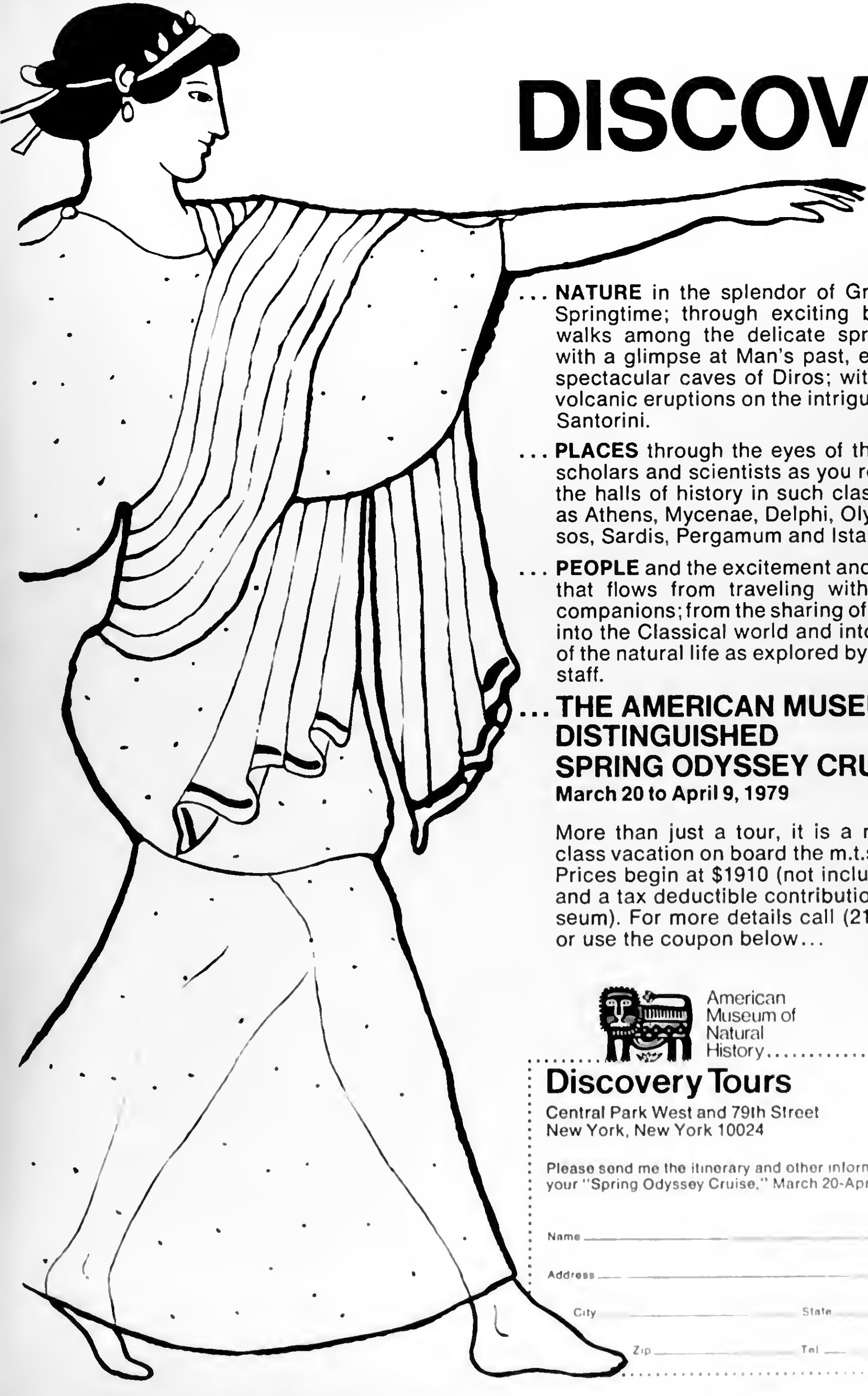
Especially relevant to a book of this nature are the warnings about potentially poisonous plants. Since oleander, *Nerium oleander,* is grown fairly commonly in gardens and homes in the United States and elsewhere, it would have been appropriate to include a word on this plant's toxicity—in a few recorded cases, swallowing a single leaf has proved fatal.

Criticism of a very small part of this comprehensive chapter is not meant to disparage this otherwise useful and attractively laid out lexicon. Clear, colorful illustrations and photographs beckon one to linger here and become immersed in the atmosphere of an illustrated herbal—in a modern vein.

Looking to the future, Thomson closes the final chapter with a plea for orthodox and herbal medicines to pool their resources rather than to distrust or scorn each other. He emphasizes the urgent need not only to scrutinize the literature but also to take cognizance of the folk medicine of aboriginal peoples, investigating, in both cases, any mention of the curative qualities of plants. Experience has shown that such a search may yet yield healing remedies of considerable importance to man. Many examples can be cited where healing medicines were overlooked although they were written about in herbals. *Rauwolfia,* so useful now for the tranquilizing drug reserpine, which is used in the treatment of nervous disorders, was recorded in the ancient Indian *Veda* of 1500 B.C. It was rediscovered only 25 years ago. Then there is ephedrine, derived from *Ephedra,* known in the folk medicine of China more than 5,000 years ago. It too was synthesized only in this century, although the bulk of the drug is still obtained from the plant. Similarly dependent on isolation from plants are codeine, cocaine, morphine, digitalis, ergotamine, podophyllin, and caffeine.

Medicines from the Earth does not deemphasize the services of the physician; it is there to correct misinformation about herbal medicines and to provide information for those who may be skeptical or those interested in knowing more. By dealing with a broad range of species, including many common ones growing in the average backyard, it confirms that medicines from the earth are, and have been, a fact—and they do heal. For the scientific public, the skeptics, and the curious, this book provides a wealth of information about herbal medicines and will serve as a valuable reference.

Stephen Tim is a taxonomist at one of New York City's major botanical gardens. Trained in the fields of botany and microbiology, he lectured in these subjects in South Africa prior to his coming to the United States.



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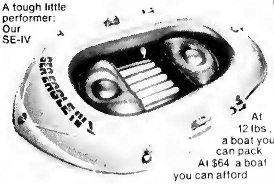
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Mein Force

Did Marco Polo bring the noodle back from China?

"Ticker tape," said Fiorello LaGuardia, in a speech delivered before the United Nations Relief and Rehabilitation Administration in 1946, "ain't spaghetti." But what is spaghetti? And where does it come from?

These questions are not as simple as they may at first appear. It will not do just to say that spaghetti is a noodle with a circular cross section and that it comes from Italy. The inquiring mind will not rest here, for this glib response raises deeper questions. What is a noodle? Did an Italian make the first one? How and when? And how do we know that? Furthermore, did the noodle demiurge start with rounded noodles? If not, what did he produce?

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3. FREELANCE-LEAD DIRECTORY. A directory of who is buying photography, what their annual estimated purchases will be in dollars and what type of photography they are searching for.

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5. REPRESENTATION WITH WIRE SERVICES. All newsworthy photography submitted to the guild will be shown to the major wire services and proper credit will be given to the Guild Photographer.

6. CONTRACT AND RELEASE FORMS. Forms will be printed in the Guild newsletter to be used as a guide or photocopied and used in their original form for use with models, clients, locations owners, etc.

7. JOB REFERRAL SERVICE. Advertising agencies and other purchasers of photography will be contacted whenever they are going on location shoots in your area. We will supply them with your name and samples of your work from our archives.

8. BUSINESS CREDIT REPORTS. Lensmasters collects credit information from its members about clients they have had dealings with. The information is available to any member who requests information on a possible new account.

9. PHOTO LIBRARY/ARCHIVES. Lensmasters places all photos submitted into the archives. From time to time Lensmasters may sell one-time-publication rights. When this is done the Guild photographer of record will be paid 50% of the selling price.

10. GUILD PHOTO-TRIPS OR SEMINARS. You can join us on our frequent photo-trips and seminars to exotic places around the world, which we can offer at group rates — up to 30% off regular air and hotel prices! In attendance on our trips are experienced professionals of the photographic community who give lectures and assist Guild members who want help with their photography. On each trip, Lensmasters will hold a mini-photo contest. If you can best capture the spirit and feeling of our adventure together, the Guild will reimburse you for all your travel expenses.

11. ANNUAL LENSMASTERS COLOR MAGAZINE. Lensmasters will publish an annual color magazine containing the finest color and black and white photographs submitted during the year.

12. LENSMASTERS PHOTO GALLERY. Selected photos from the Guild archives will be chosen for display at the Lensmasters Guild headquarters at 9724 Washington Boulevard in Culver City, California.

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3. Entries must be 8x10 glossy prints with all relevant technical data including category and title written on the back of the photograph. Entries without the relevant data will be voided.
4. Contest categories are PEOPLE, NATURE, COMMERCIAL, and SPECIAL EFFECTS/ART. Only one category per entry.
5. Grand Prize is a two-week paid vacation for two to New Zealand.
6. First prize in each category is a one-week paid vacation for two in your choice of either Hawaii or Mexico.
7. Second Prize in each category is a $200 retail gift certificate at your favorite store.
8. Third Prize in each category is a $100 retail gift certificate at your favorite store.
9. All winning photographs will be published in the Annual Lensmasters Photo Awards Magazine and displayed in blow-up format at selected galleries in Los Angeles, Chicago and New York.
10. Winners will be notified by March 1, 1979. Prizes may be used any time during 1979.
11. Contest void where prohibited by law.

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takes a leap of the classificatory imagination to see them all as noodles—play a part in the diets of most people in almost every part of the world.

No cuisine in Europe is without them. Who would serve sauerbraten without flat egg noodles on the side? The Germanic fondness for noodles extends into Alsace, and the best homemade noodles I ever ate were made by the Alsatian chef-owner of the New York restaurant Lutèce, André Soltner, in his weekend home. He rolled and stretched the dough so thin you could literally read the newspaper through it, then cut it with a knife into thin strips.

This is the classic method of making noodles at home. In earlier times, such noodles were a substitute for bread, a means of using flour (and thereby of putting starch into a meal) without using an oven, which was not, as we easily forget, available in every home or even in every neighborhood. Noodles, even in this century in France, were the cheapest form of food energy. The novelist Louis Ferdinand Céline, in an interview, recalled the all-noodle diet of his childhood with revulsion.

Nothing is worse than badly made noodles. And it does require considerable skill with a rolling pin to thin the dough to the point where the end product will be tender. This is why pasta-rolling machines for home use are becoming so popular among those who want the taste benefits of fresh pasta without the primitive toil the primordial method exacts. But it is important, for our purposes, to keep in mind what the original method is, because it suggests a general definition for noodles.

At their most basic, then, noodles start out as a mixture of flour and water, thick (or perhaps one should

A Fluke of Nature

A new grapefruit discovery may change your concept of fruit —

I'm a farmer. And the story I tell you is the absolute truth, as incredible as it may seem.

It all started in a grove owned by Dr. Webb, our family doctor. One of the men who was picking fruit in the doctor's orchard came up to the Webb house holding six of the strangest grapefruit anyone had ever seen! A single branch of an ordinary grapefruit tree had produced these six unusual fruit.

These were big grapefruit, unusually big. And they had a faint red blush on their skin. When Dr. Webb sliced open the grapefruit, the fruit was a **brilliant ruby red** in color.

Doctor Webb decided to taste this strange new grapefruit. The fruit was perfect, juicy and luscious. It wasn't sour like other grapefruit either — it was naturally sweet without sugar.

For some reason, we'll never know why, nature had chosen to produce an entirely new kind of grapefruit here in our Magic Rio Grande Valley. It was incredible — men had labored for years to produce the ideal grapefruit, and had failed. But suddenly on a single branch of one tree in one grove, Mother Nature had done it all herself!

YOU CAN IMAGINE THE EXCITEMENT

From the fruit on that one branch, grove after grove now produces our own Texas Ruby Red Grapefruit. When I say, "not one man in a thousand has ever tasted this grapefruit." — you can easily understand why.

To begin with, Ruby Reds are rare. You can look for them in stores, but I doubt if you'll find one. You may find pink grapefruit, but seldom if ever do you see the genuine Ruby Reds.

So you start with the rarity of Ruby Reds, and to get to ROYAL Ruby Reds you have to get rarer yet. Only 4 to 5 percent of the entire crop will qualify as a "Royal Ruby Red."

Each Royal Ruby Red weighs a pound — or more! Each has a rich red color, flowing juices, luscious naturally sweet flavor, and the ability to stay this way for many weeks.

Why, we won't even consider harvesting a grove until I've checked out the fruit for tree-ripened maturity myself. I check for "natural sugar," low acid balance and high juice content. I check to see that the fruit is plump and meaty, and I even check to see that the skin is thin. Not only does each factor have to check out, but all the factors have to be in a proper relationship to each other before I'll harvest a grove.

And when we pick the fruit we're just as fussy. Every one of us takes a "picking ring" when we harvest. If the

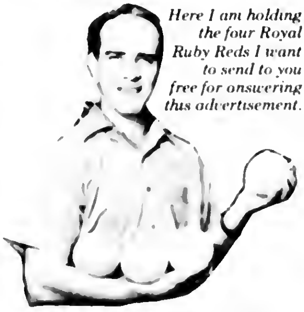
This is a picture of the actual harvest of this season's first Ruby Reds.

fruit is small enough to pass through this ring — we don't pick it! It simply isn't big enough to qualify as a Royal Ruby Red!

Even after picking there are other careful inspections each fruit must pass before I'll accept it. I size the fruit. And I grade it for beauty. Sometimes the fruit will be wind scarred. I won't accept it. Or sometimes it will have a bulge on the stem end that we call "sheep nose." I won't accept it. You can see I really mean it when I say I accept only **perfect** Royal Ruby Reds.

When I realized that the Royal Ruby Reds were the ultimate fruit, I decided to form a club and sell only to my club members. In this manner I can control my production to insure that nobody will be disappointed.

But before I ask you to join my club, I want you to sample my Royal Ruby Reds for yourself, at no cost to you whatsoever. Let me send you a box prepaid of 16 to 20 Royal Ruby Reds. Place four of them in your refrigerator until they are thoroughly cool. Then cut them in half and have your family sample this unusual fruit.



Here I am holding the four Royal Ruby Reds I want to send to you free for answering this advertisement.

You decide whether or not Royal Ruby Reds are everything I say. You determine whether or not eating a Royal Ruby Red is the fantastic taste experience I promise.

You decide. I'm confident that you and your family will want more of this superb fruit - and on a regular basis, too. If the four Royal Ruby Reds make you say "yes," then keep the remaining fruit. Otherwise return the unused fruit (at my expense) and you won't owe me a single penny.

But you are never going to know just how wonderful genuine Royal Ruby Reds are unless you place your order right quick.

This way you are sure to receive your package containing 16 or 20 Royal Ruby Reds for you and your family to sample. But since the supply is strictly limited it's important to place your order now.

SEND NO MONEY NOW

I'll put the bill for $10.95 for this first shipment on the top of the box. That's a saving of $5.00 off the regular price of $15.95. All delivery charges are prepaid by me. Remit only after my Ruby Reds have proved themselves, otherwise you don't owe a thing.

Now suppose you do like Royal Ruby Reds — suppose you **love** them — can you be sure of getting more?

You surely can. By saying "yes" to my first shipment you have the privilege of automatically joining my Winter Fruit Club. Please be assured **you pay nothing in advance.** But each month during the winter I'll ship you a $15.95 pack of 16 to 20 orchard fresh, hand selected, hand picked Royal Ruby Reds.

Every Royal Ruby Red you receive will pass my tough tests. Each will weigh a pound or more. Safe delivery is guaranteed. This fruit is picked, packed and shipped each month, December through April.

You pay only after you have received each shipment. And you may skip or cancel any shipment, simply by telling me your wishes.

HERE'S HOW TO ORDER

Call my toll-free number below, or send your name and address to me at the address below.

Remember it obligates you to nothing, except making a taste test of the best grapefruit that has ever been grown. And this taste test is on me!

Of course, as you can well imagine, when I say supplies are limited — I'm not kidding! There's just so many club members I can accept before I must close my membership this year.

So to taste this "miracle" grapefruit, and have the opportunity to savor it each month during the growing season, be sure to place your order at no obligation today.

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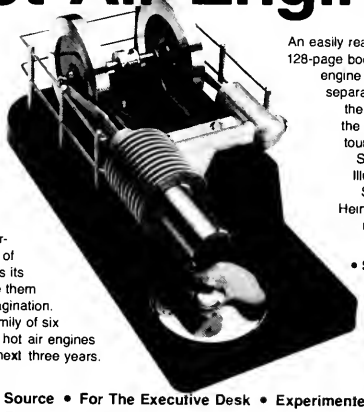
Hot Air Engine



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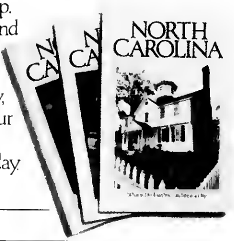

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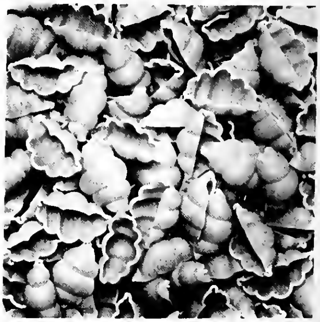
say dry) enough to be worked. This dough or paste (*pasta, pâté*) must then be rolled or otherwise shaped and cut into small pieces or strips that can be quickly cooked by boiling. Normally, true noodles are left to dry for at least a few minutes before they are cooked. They will, of course, keep for long periods without going stale, which, along with their ease of preparation, gave them another advantage over bread in a traditional kitchen.

If noodles are small pieces of flour-water paste, dried and then boiled, what differentiates them from dumplings? Many people see no difference. In the most complex case, Hungarian cuisine, noodles shade off into dumplings in so many slight variations that it makes me feel pedantic even to try for a clean distinction. It would be easy to pigeonhole dumplings, if they were all largish lumps of dough dropped into soup. But who are we to ignore *tarhonya,* the pebble-hard "egg barleys" made by grating dough through a sieve? George Lang, in his *The Cuisine of Hungary,* also refers to "noodles" made with semiliquid dough. These so-called soup peas (*rántott borsó*) are dripped through a large-holed sieve into hot lard and fried before they are used to garnish soup. A similar dough can be trickled intermittently through a narrow-tubed funnel directly into boiling soup. After five minutes of cooking, these tubular noodles solidify.

Perhaps we ought to eliminate noodles made from pourable doughs, or batters. This leaves us with *tarhonya,* which fit with true noodles in another crucial way. They are dried. This notion of dryness allows us to ignore certain intermediate cases where a still moist dough is cooked in a noodle-



Evening Lecture Series for Adults starting February 1979

at the American Museum of Natural History

Seaside Cities of the Ancient Levant
6 Tuesdays starting February 13,
7:30-9:00 p.m. Fee: $30.

The Levant, brilliant easternmost corner of the Mediterranean, includes Israel, Lebanon, coastal Syria and Cyprus. Cedar, copper and carved ivory filled the ships of Levantine traders and enriched their cosmopolitan cities, some of the oldest in the world. Besides its towering contributions of Judaism and Christianity, a rich legacy of mythology and archaeology illustrates the Levant's ancient cults of storm gods and love goddesses. Topics to be discussed in this series by Dr. Claireve Grandjouan, Chairman of the Classics Department at Hunter College, include: *From Cave To Village in the Levant; Fortresses and Temples of Israel; Shopping Centers for the Mediterranean; Cyprus, The Copper Island; The Phoenicians;* and *Greeks and Romans in the Levant.*

Pompeii A.D. 79
3 Tuesdays starting April 10,
7:30-9:00 p.m. Fee: $20.

This series of slide lectures focusing on the ancient Roman city of Pompeii is being given in conjunction with the exhibition opening at the Museum in April. Dr. Anna Marguerite McCann who has directed, participated in and photographed excavations at many sites in Italy, will discuss The City of Pompeii—its history, discovery and excavation; The People—homes and gardens, daily life and religious beliefs; and The Arts—Pompeiian painting styles and collections in villas. (Note: The Pompeii A.D. 79 exhibition will be specially opened on Monday evening, April 23, ONLY for ticket-holders for this series.)

Anthropology Through Films
8 Thursdays starting February 15,
7:00-9:00 p.m. Fee: $50.

Dr. Malcolm Arth, Curator at the Museum, has again selected provocative films by anthropologists and filmmakers which provide insight into culture and human behavior. Anthropologists Asen Balikci and Colin Turnbull, and filmmakers E.J. Vaughn and John F. Schott, Jill Godmilow, Claudine Viallon, Mitchell W. Block and the Mariposa Group join Dr. Arth in discussing their films: DEAL; WORD IS OUT; AN AFGHAN FAMILY; THE POPOVICH BROTHERS OF SOUTH CHICAGO; AU BOUT DE MON AGE; THE IK OF UGANDA; SPEEDING?; BRUJO and VIA DOLOROSA.

Socialization of Young Animals
8 Mondays starting February 26,
7:00-8:30 p.m. Fee: $45.

To celebrate the United Nations International Year of the Child, various patterns of "growing-up" in a series of invertebrates and vertebrates will be reviewed by Dr. Ethel Tobach, Curator at the Museum and Adjunct Professor in Biology and Psychology at The City University of New York. Recent experiments and theoretical discussions stimulated by the ethology and sociobiology debates will be combined with demonstrations of the behavior of young animals from current studies in the laboratories of the Museum's Department of Animal Behavior.

Magic and Witchcraft
6 Mondays starting February 26,
7:00-8:30 p.m. Fee: $30.

Paul J. Sanfacon, Lecturer in Anthropology at the Museum, leads a serious socio-historical inquiry into various beliefs and practices of magic, witchcraft and sorcery.

The World of Mammals
8 Tuesdays starting February 13,
7:00-8:30 p.m. Fee: $40.

Kenneth A. Chambers, Lecturer in Zoology at the Museum, surveys some of the world's more interesting and unusual mammals. In addition to slide-illustrated lectures, visits will be made to three of the Museum's exhibition halls, where a variety of North American mammals will be seen in their simulated natural habitats.

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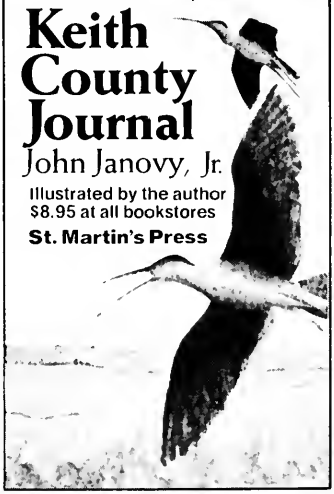

like form. The Swiss, for instance, push dough through a colander or snip bits of it off with a knife and then boil it, to make *hörnli* ("little horns"), *knöpfli* ("little buttons"), and *spätzli* ("little sparrows"). Similarly, Hungarians pinch off pieces of dough to make their legendary *csipetke*. And Jews bake pieces of dough to make *mandlen.*

Dried, raw dough in small, edible pieces, ready to cook in a short time when wanted, almost infinitely storable, a convenience food for a preindustrial kitchen—this is the only satisfactory definition of noodles. And it brings us back to Italy, where the full term for noodles is *pastascuitta,* "dried dough." It is fitting that the Italians should have a precise word for noodles because they have gone further in elaborating the shapes and sizes of noodles than any other nation.

Within the superabundant ramification of pasta types in Italy, from among the bewildering array of fusilli, ziti, linguine, rigatoni, trenette, orecchiette, mostaccioli, and dozens and dozens of others, two main categories can be marked out. The north of Italy, whose gastronomic center is Bologna, produces *pasta tirata,* rolled pasta made from local semolina flour and characteristically combined with egg. These are the flat pastas traditionally made by hand but also now turned out in factories. Indeed, Waverley Root notes, in his *The Food of Italy,* that Marshall Plan administrators were shocked to discover a Bolognese factory routinely making 250 different varieties of these noodles.

In the south, from Naples on down to Sicily, the pasta is tubular, extruded through machines to form stiff, eggless macaroni and spaghetti. Root learned about this meridional form of noodle with a vengeance during a visit to Naples in 1929, where he found "jungles" of it in "insalubrious" courtyards. "Limp strands hung over clotheslines to dry, dirt swirled through the air, flies settled to rest on the exposed pasta, pigeons bombed it from overhead, children invented games to play with it, and the large dog population, finding itself short of lampposts, put up with what it could find."

Alfresco pasta manufacture is now largely a thing of the past. In-

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This year, the Grand Prize of *Natural History*'s Photographic Competition will be a ticket for the American Museum of Natural History's Discovery Tour through the Aegean and the Middle East. The winner will fly from New York to Athens, from where the tour's cruise ship will sail for Egypt, Israel, Cyprus, and Turkey. The tour will include a three-day excursion to Cairo and Luxor, a two-day trip to Bethlehem and Nazareth, and visits to Jerusalem, Rhodes, and Istanbul. The Grand Prize-winner will have the chance to photograph such magnificent sites as the Temple of Poseidon at Sounion, the church of Saint Sophia, and the Seraglio in the Topkapi Palace Museum, as well as the Aegean's spectacular scenery.

Besides the Grand Prize, the 1979 competition offers cash prizes totaling more than $3,000. The winning entries will be published in a special double issue of *Natural History* in August and exhibited at the American Museum of Natural History.

The four categories—broad enough to fit the interests of any photographer—are: (1) The Natural World; (2) A Sequence of an Event in Nature; (3) Photomicrography, including pictures with a scanning electron microscope; and (4) The Human Environment. First prize in each category is $500. In addition, all entries are eligible for the following awards: Humor in Nature, $200; Urban Wildlife, $200; and ten Honorable Mentions at $100 each.

The deadline is April 15, 1979. Please put your name and address on every entry and include a stamped, self-addressed envelope—since we do want to return your pictures to you.

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THE RULES

1. The competition is open to everyone except employees of the American Museum of Natural History and their kin.
2. Competitors may submit up to three previously unpublished entries in each of the four categories. Decision of the judges is final.
3. The Museum acquires the right to publish, exhibit, and use for promotion the winning photographs. The Museum assumes no responsibility for other entries.
4. Entries may be transparencies or prints up to 8 by 10 inches, and each must bear the photographer's name and address.
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deed, pasta factories sprang up in Naples in the nineteenth century. But various sorts of evidence prove that Italy has enjoyed pasta in one form or another, for many centuries. I am not sure how persuaded I am by pasta-making implements supposedly turned up in Etruscan tumuli. And I have been unable to examine the thirteenth-century papal bulls that Root says set standards for the quality of spaghetti. Unable, moreover, to convince my parsimonious editor that an expedition to the Vatican library was obligatory for primary research on this point, I have not been able to inspect at firsthand a manuscript cookbook, said to have been written between 1260 and 1290, in which recipes for vermicelli, tortelli, and tortelletti are reported to appear.

These references are of more than purely antiquarian interest because they seem to disprove the well-known legend that Marco Polo brought pasta to Italy from China. All responsible authorities now agree that Polo did not return to his homeland with the Occident's first noodle recipe. These gastrohistorians, however, argue against the Polo theory by citing evidence for pasta that antedates the great traveler's repatriation in 1495. They might just as well have read the man's own book. There he states that in Cathay, the people ate "vermicelli" instead of bread. If noodles had been unknown to him and other Italians before his voyage, Polo could not have talked about them so matter-of-factly or used a term that would have been incomprehensible to his readers. He would, rather, have written something along the lines of: "In Cathay, the people do not have bread, but they consume in its place small strands of dried dough that must be boiled before they are soft enough to eat. They resemble little worms (*vermicelli*)."

None of this undermines the Chinese claim to an early and independent discovery of noodles. By the time of the Sung dynasty and particularly toward its end in the twelfth and thirteenth centuries A.D., noodles made from wheat and millet were a diet staple in the north. This is still the case. Craig Claiborne of the *New York Times* tells me that during his trip to China last fall he would duck out of the official lunches planned for his

group, take a taxi to an ordinary restaurant, and almost invariably find the regular clientele eating noodles.

These might have been made from wheat or rice or even mung beans, which are the basic ingredient of so-called cellophane noodles, those resilient, translucent strands that crop up in cold salads or with chopped meat in the highly seasoned dish fancifully known as "ants climb a tree." Rice noodles served cold in a sesame sauce are one of the glories of Chinese cooking. And fried noodles, familiar here in a degraded, precooked form as chow mein, can, if delicately stir-fried in oil so that the already parboiled noodles turn crisp on the outside but stay soft within, be a dish of the greatest finesse, despite its apparent simplicity. Great ideas, of course, cross frontiers with impunity, but it was with real surprise that I once noticed a variation on this Chinese ploy in the pages of the bible of French haute cuisine, Escoffier's *Guide Culinaire*. *Croquettes à la milanaise* are squares of chopped, blanched noodles, bound with bechamel, breaded, and fried. If the temperature of the fat is not exactly right, the croquettes disintegrate in the fat and turn into a very fancy chow mein. But with such failures, who needs success?

Noodles with Hot and Spicy Sauce
(adapted from *Henry Chung's Hunan Style Chinese Cookbook*)

- 2 tablespoons vegetable oil
- 1 pound minced pork butt or shoulder
- 1 tablespoon minced fresh ginger
- 1 tablespoon minced fresh garlic
- 1 tablespoon Szechuan hot bean sauce
- 1 teaspoon cayenne pepper
- 1–1½ cups chicken stock
- ¼ teaspoon black pepper
- 1 tablespoon white wine
- 1 pinch salt
- 2 tablespoons soy sauce
- 1 tablespoon cornstarch, dissolved in as small an amount of water as possible
- 1 tablespoon minced scallions
- ½ pound Chinese rice noodles (or Italian vermicelli), boiled until *al dente* (about 5 minutes for Chinese noodles, 10 for Italian) in an ample amount of salted water. (Toss cooked, drained noodles with a bit of oil to keep them from sticking.)

1. Heat a wok or skillet for 1 minute over high heat. Add vegetable oil. When the oil starts to smoke, add minced pork and stir-fry vigorously for 5 minutes.
2. Add ginger, garlic, hot bean sauce, and cayenne pepper, and toss until well blended (at least 1 minute).
3. Add chicken stock, black pepper, wine, salt, and soy sauce, and stir for another 30 seconds.
4. Add liquid cornstarch to thicken sauce and garnish with minced scallions. The sauce by itself should taste a little more spicy than you would want; when thoroughly mixed with the noodles it will taste just right served either hot or cold.

Yield: 4 servings

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

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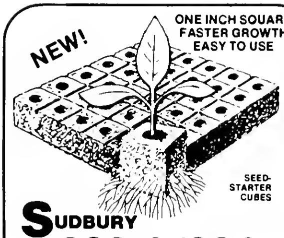

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Is It an Asteroid, a Comet, or a Moon?

Chiron, a recently found small object, defies the experts

A remarkable minimember of our solar system named Chiron has been unknowingly photographed many times in the last 80 or more years. Each time, save one, it went unnoticed. That one time, a dim image of the object was noted but was not studied or reported. Finally, in 1977, Chiron was discovered but, even now, astronomers cannot tell what it is.

The solar system consists of the sun, surrounded by the nine planets and their moons. It also includes more than 2,000 known asteroids, or minor planets, as well as numerous comets and an untold number of small meteoroids.

The planets revolve around the sun in orbits classified as ellipses although, with two exceptions, they are not very different from circles. The exceptions are the orbits of Mercury and Pluto, which have modestly elliptical paths. By contrast, Chiron's orbit is a noticeably elongated ellipse that approaches to within 790 million miles of the sun, slightly inside the orbit of Saturn. It takes Chiron fifty years and eight months to complete one solar revolution and most of that time is spent well beyond Saturn's orbit. In fact, the long journey takes Chiron out as far as 1,760,000,000 miles from the sun, approaching the orbit of Uranus.

Chiron was discovered on November 1, 1977, by Charles T. Kowal, an expert observer at the Hale Observatories in Pasadena, California. He spotted it while comparing two photographs that he had made on Mount Palomar on October 18 and 19, two weeks before. The comparison revealed a dim object that moved slightly during the one-day interval. Additional Palomar observations, as well as photographs made with telescopes in Texas and Massachusetts, made it possible to compute Chiron's orbit and to determine that the object was about 1.5 billion miles from the earth when it was photographed in October.

The orbital computations were done by Brian G. Marsden of the Center for Astrophysics in Cambridge, Massachusetts, an authority on comets, asteroids, and their orbits. Marsden also computed approximate sky positions of Chiron at various past times. This made it possible to search for the object in observatory photograph collections. The computed positions necessarily were in error, since Chiron's orbit was not precisely defined. The further back in time that Marsden tried to trace Chiron's position, the greater the error. Thus, at first only very recent photographs were examined. Chiron was located on them and its precise location measured. The results were fed back into the computing process, allowing a more accurate orbit to be calculated. The more exact orbit, in turn, led to a sufficiently accurate computing of Chiron's past motion to enable much older images to be found.

A key find was a faint trail of Chiron on a photograph made in 1941 with a 24-inch telescope at Harvard College Observatory's Boyden Station in South Africa. That trail had in fact been noticed in 1951, when a young Harvard astronomer scanned the photograph while searching for galaxies. The trail was circled as an item of interest but was later forgotten. Found again in 1977, the trail was measured and the information enabled Marsden to calculate Chiron's position in 1895, when it was near perihelion (closest approach to the sun) and may have been twenty times brighter than when it was discovered by Kowal. A search based on

by Stephen P. Maran

Marsden's calculations revealed the object on a photograph made at Harvard in April 1895 with the 24-inch telescope, which had not yet been moved to South Africa.

By 1945, when Chiron's next perihelion passage occurred, photographic techniques had improved. Well-organized minor planet patrols had made much progress in the search for asteroids and might have been expected to discover Chiron that year. However, the work of the patrols, especially that of the leading patrol, in Heidelberg, Germany, was interrupted by World War II. Hence, Chiron was missed again, although a recent check shows that it appears on at least one photograph made in 1945 at an observatory in Finland.

Little has been determined thus far about the nature of Chiron. Eventually, observations with large telescopes will provide further clues, but for the time being, all we know is its brightness and appearance on photographs and the size and shape of its orbit. Its image is sharp, like that of an asteroid or star, not fuzzy like that of a comet, but we do not know whether it is an asteroid, a cometary nucleus, an escaped moon, or something else.

Chiron shines by the reflected light of the sun. Its brightness, as seen from the earth, depends on its distance from the sun, its distance from the earth, its ability to reflect light, and our angle of view. The angle of view is involved because a normal object reflects more light back toward the sun than it does off at an angle. For given distances and a given angle of view, the larger the reflecting object, the brighter it will appear. This enables us to estimate Chiron's size from its observed brightness. The estimate, however, is uncertain because we do not know how good a reflector Chiron is. If it resembles one of the darker asteroids and is accordingly

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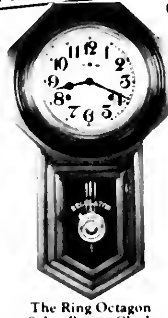

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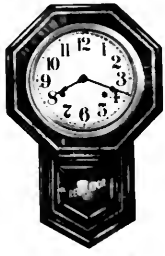

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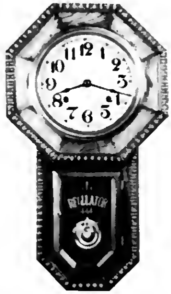

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a fairly poor reflector, it may be 400 miles in diameter. On the other hand, if Chiron is very light in color and therefore a good reflector, it may be only 60 miles in diameter. This size range, 60 to 400 miles, is typical of the larger asteroids and of some planetary moons. But the diameters of the nuclei of comets, that is, the frozen solid objects within their gassy heads, are much smaller.

The sharp image and fairly large diameter of Chiron (even 60 miles would be very large for a cometary nucleus) may seem at first to rule out the possibility that it is a cometary nucleus. Yet this is not so easily done, even though no comet has been observed at Chiron's present distance from the sun and many comets are calculated to travel much farther out in space. As a comet recedes from the sun, solar heating diminishes, the ices of the nucleus stop evaporating, and hence the gases of the head and tail are not replenished. Meanwhile, the material already present in the head and tail streams away. Soon, only the tiny nucleus remains, too dim to be seen when far from the sun. If seen, it might have an asteroidal appearance.

But what if there were a comet with a very large nucleus, positioned in an orbit that never brought it much within the orbit of Saturn? In that case, the ices would stay frozen. Since no ice would evaporate, the nucleus would not shrink slowly, as do those of observed comets, but would retain its large size. Thus, the object might be observable from the earth and, like Chiron, would have a sharp, asteroidal appearance, not the fuzzy look of a comet.

In other words, Chiron may be the largest known comet and also the only one without a head or tail. This, at least, is implied by one theory mentioned in a paper presented to a May 1978 symposium, "Dynamics of the Solar System," in Tokyo. The authors were Kowal, Marsden, and William Liller, a Harvard astronomer who helped find the 1895 and 1941 photographs of Chiron.

The obvious objection to the above theory is that Chiron is much larger than known comets and doesn't look like them. Yet it does have the typical elongated elliptical orbit of a comet and, like most comets, travels far out in the solar system, beyond the orbits of known asteroids.

Most asteroids are located in the asteroid belt (see "Pebbles Out in Space," *Natural History*, May 1978) between the orbits of Mars and Jupiter. Also, the great majority of asteroids have orbits that are more circular in form than that of Chiron or of a typical comet. On the other hand, Hidalgo, the proven asteroid of largest known orbit, does travel in a path even more elongated (although smaller) than that of Chiron. Hidalgo comes in toward the sun nearly to the orbit of Mars, yet passes out nearly to the orbit of Saturn.

If Chiron is an asteroid, then what is it doing so far out beyond the asteroid belt and every other known asteroid? One possibility mentioned by David W. Hughes, a physics lecturer at the University of Sheffield in England, is that Chiron is the largest member of a second asteroid belt "that has always existed between Saturn and Uranus."

The problem with Hughes's idea is as follows. If the perihelion point of Chiron is within a hypothetical second asteroid belt, so that Chiron is not both the largest and the closest-approaching member of the belt, we would expect to observe other members. Some of these asteroids, although smaller than Chiron, should be bright enough to be found by the minor planet patrols when the objects are on the opposite side of the earth from the sun. At least, this would be true if they had roughly circular orbits like those of ordinary asteroids. A given asteroid would be opposite the sun and susceptible to discovery once every year.

Even if all members of the hypothetical outer belt had very elongated elliptical orbits like that of Chiron, some of them would still be detectable on the occasions when they pass perihelion. The perihelion times for different asteroids would occur in different years, and not all would have last occurred during World War II. Hence, even some second-belt asteroids in very elliptical orbits should have been discovered by now if there were many besides Chiron. But none have been found.

Thus, if Chiron is an asteroid sharing a common origin with other

asteroids, it must have moved out from the known asteroid belt to its present orbit.

Some astronomers believe that Chiron did originate in the known asteroid belt, whence it was ejected to a more distant orbit as a result of gravitational disturbance by Jupiter. This theory also suggests that Chiron was sent into its present orbit, still farther from the sun, after a close encounter with Saturn. However, this cannot be proved. Calculations by Marsden show that Chiron's movements cannot be traced further back in time than 1665 B.C. In that year, Chiron passed within perhaps less than ten million miles from Saturn, and must have been shifted into its present orbit. The object's orbit prior to disturbance by Saturn thus can only be a matter of conjecture.

Consider the following analogy: You see a tennis ball on the rebound after it has hit a moving truck. You did not see the actual collision and do not know exactly where and when, or at what angle, the ball hit the truck. You can see where the ball is going from that point on, but you have no way of determining the path of the ball before it hit the truck.

The uncertainty in the origin of Chiron, coupled with its close encounter of an unknown kind with Saturn, inspired Robert Connon Smith, an investigator of dynamical processes at the University of Sussex in England, to propose a more fanciful theory. He suggested that Chiron may have been an outer moon of Saturn and may even have previously been an asteroid, captured by Saturn at some remote time in the past. Subsequently, he thinks, Chiron was ejected from its Saturnian orbit to take up its present path around the sun.

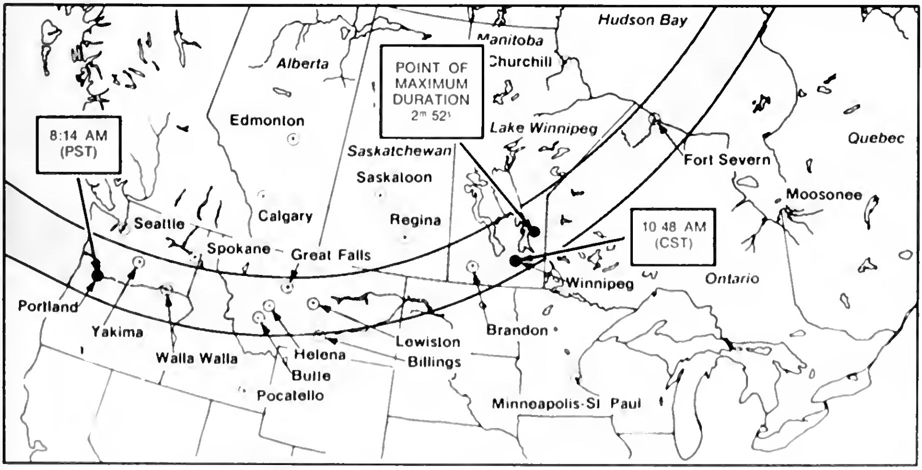
Calculations published in 1967 by an astronomer in Glasgow, Scotland, indicate that this kind of "gravitational slingshot" could occur if a moon of Jupiter had an orbit with a diameter so large that it was a significant fraction of the diameter of Jupiter's orbit around the sun. He found that in such cases the gravity of the sun can disturb the moon's orbit and even sling the moon away from Jupiter. Smith extended this reasoning to the case of Saturn and suggested that Chiron was a moon ejected in this way. In fact, the 1665 B.C. encounter with Saturn brought Chiron in almost to the orbit of that planet's outermost known moon, Phoebe.

The objection to Smith's theory, which has received little public support, is that it invokes a very rare kind of event that has never been known to occur.

For purposes of record keeping, Chiron has been assigned the serial number of an asteroid—minor planet No. 2060. Nevertheless, the possibility remains that Chiron is a huge comet that, kept in remote cold storage, has never blossomed forth with head and tail, or even that it is a Saturnian escaped moon. A week after he discovered Chiron, Kowal told the press, "I haven't the slightest idea" what it is. We have several theories now and future research may allow us to tell which, if any, of the possibilities is correct.

Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

FEBRUARY 26, 1979



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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun starts off the year in the stars of Sagittarius, well south of the equator. About the 19th of January, it moves into Capricornus, where it remains until mid-February. Perihelion (where the earth is nearest the sun) occurs on January 4, and the latest sunrise takes place about January 5 (although the shortest day of the year was in late December). The moon will be in the evening sky until mid-January and again in early February. On New Year's Eve we will have a splendid young crescent moon low in the southwest at dusk. It will wax, appearing higher and setting later, through first-quarter on January 5 and be full on January 13. Thereafter it wanes as it rises progressively later at night and remains longer in the morning sky, through last-quarter on January 21 until new moon on the 28th. In February, first-quarter moon is on the 3rd, full moon on the 11th, and last-quarter on the 19th. Most interesting of all will be the new moon of February 26, which will eclipse the sun, partially in most of Canada and the United States (except Hawaii and western Alaska) and totally in the northwestern states and central Canada.

Stars and Planets Evening stars will be spectacular in January, with all the winter constellations well up in the east at dusk and remaining in the sky until dawn. Jupiter is the only planet prominent on the evening Star Map, a very brilliant object in Cancer, midway between Pollux and Castor (the bright twin stars in Gemini) and Regulus in Leo. Saturn rises during the late evening, about an hour after Regulus, and remains until dawn.

The morning sky is where the planets will put on their best show in January. From the 20th (when Mars is in conjunction) until the 24th (when Jupiter is at opposition), *all* the planets will be morning stars, which means that all will be above the horizon at sunrise. Only three will be easily seen at dawn, however—Jupiter low in the west, Saturn in the southwest, and Venus low in the southeast. Venus and Jupiter will be the brightest and second brightest objects in the sky at the time (except for the moon), and Saturn will be about as bright as Regulus, lower and to its right.

January 4: The earth is at perihelion, nearest the sun.

January 9: The star near the moon tonight is Aldebaran, in Taurus.

January 13–14: The gibbous moon (just past full) moves south of Jupiter about 6:00 A.M., EST. You can easily see the moon slipping slowly to the left of the planet during the night.

January 14: The moon is at apogee, farthest from the earth.

January 15–17: Watch the moon move past Regulus and Saturn.

January 18: Venus is at its greatest distance (elongation) to the right (west) of the sun.

January 20: Mars, in line with the sun (conjunction), enters the morning sky.

January 24: Jupiter is at opposition and becomes an evening star. The moon is near Venus in the morning sky.

January 28: Perigee moon (nearest earth) occurs.

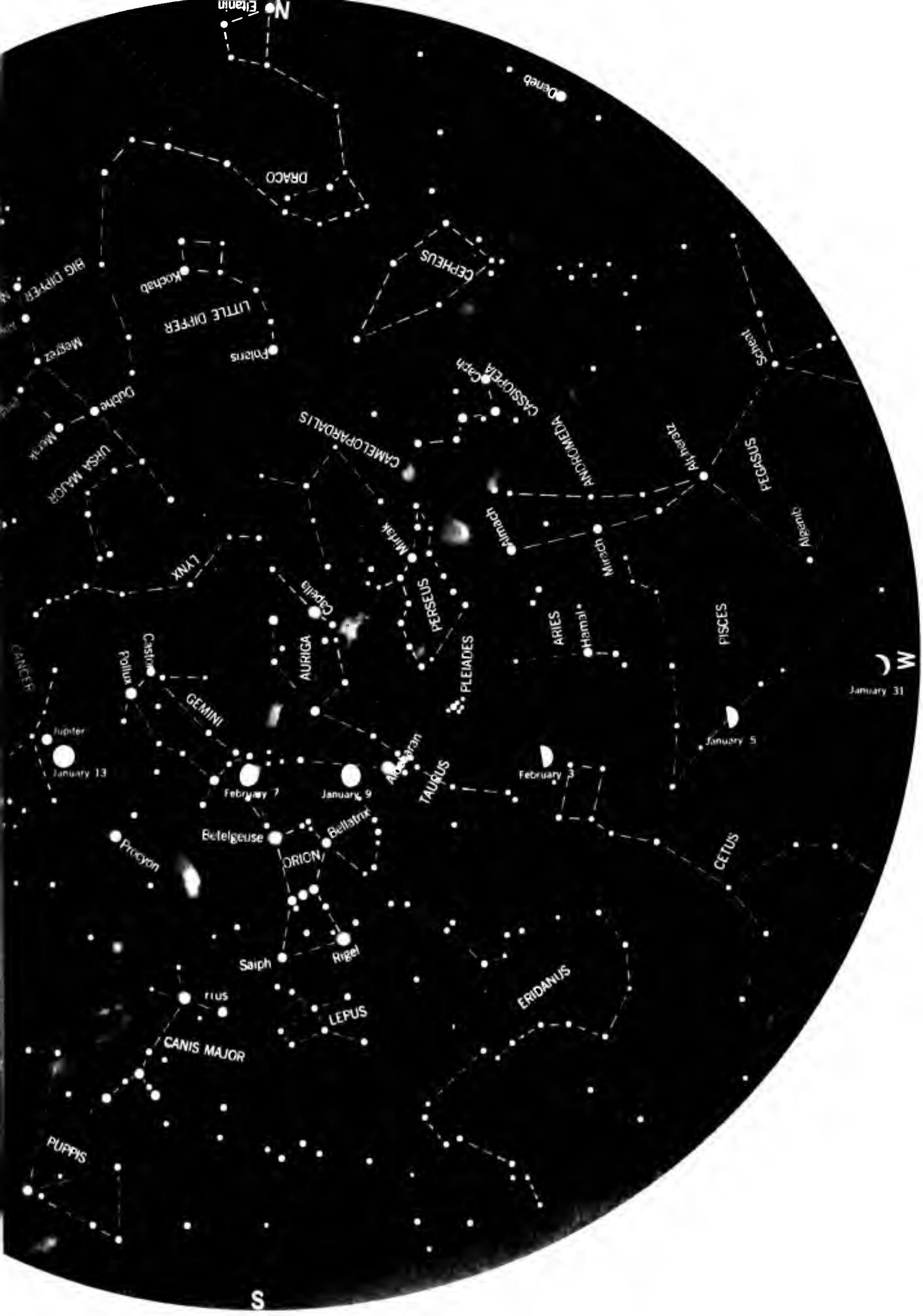
February 5: Another occultation of Aldebaran by the moon, visible in the early evening in eastern North America.

February 9: Mercury enters the evening sky.

February 10–13: The moon moves past Jupiter, Regulus, and Saturn in turn on these evenings.

February 26: Eclipse of the sun. See details in February.

★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:15 P.M. on January 1; 10:20 P.M. on January 15; 9:15 P.M. on January 31; and 8:15 P.M. on February 15; but it can also be used for an hour before and after those times.



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ARIES
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PISCES
W
January 31
January 5
Jupiter
January 13
February 7
January 9
TAURUS
February 3
CETUS
Betelgeuse
Bellatrix
ORION
Procyon
Saiph
Rigel
LEPUS
CANIS MAJOR
ERIDANUS
PUPPIS
S

Additional Reading

Slave Life (p. 8)

Antebellum and postbellum ex-slave narratives figure in John Blassingame's *The Slave Community* (New York: Oxford University Press, 1972); George P. Rawick's *From Sundown to Sunup* (Westport: Greenwood Press, 1972); and Norman Yetman's *Life Under the "Peculiar Institution"* (Huntington: R. E. Krieger Publishing Co., 1976). The Kingsley and Rayfield slave cabin excavations are reported in Charles Fairbanks's "The Kingsley Slave Cabins in Duval County, Florida 1968" (*Conference on Historic Site Archaeology Papers 1972*, no. 7, 1974, pp. 62–93); in "Excavation of a Slave Cabin: Georgia, USA," by Robert Ascher and Charles Fairbanks (*Historical Archaeology*, no. 5, 1971, pp. 3–17); and in "Spaniards, Planters, Ships, and Slaves: Historical Archaeology in Florida and Georgia" (*Archaeology*, July 1976, pp. 164–72). The ceramics from the Cannon's Point slave cabin are discussed in John Otto's "Artifacts and Status Differences," *Research Strategies in Historical Archaeology*, edited by Stanley South (New York: Academic Press, 1977).

Switzerland and Nepal (p. 46)

Robert Rhoades discusses his subject more thoroughly in "Adaptive Strategies in Alpine Environments: Beyond Ecological Particularism," coauthored by Stephen I. Thompson (*American Ethnologist*, vol. 2, no. 3, 1975, pp. 535–51). Much of Rhoades's background material was drawn from *The Sherpas of Nepal: Buddhist Highlanders*, by Christoph von Fürer-Haimendorf (Berkeley: University of California Press, 1964), one of the best books on the Sherpa. Articles on the Alps, the Himalayas, and the Andes can be found in "Cultural Adaptations to Mountain Ecosystems" (*Human Ecology*, April 1976). Toni Hagen, a Swiss geologist, draws parallels between Nepal and his country in his beautifully illustrated *Nepal: The Kingdom in the Himalayas* (Berne: Kümmerly and Frey Geographical Publishers, 1961). *People of Nepal*, by Nepalese scholar Dor Bahadur Bista (New York: International Publications Service, 1972), is an illustrated general survey; part 3 deals with northern border people. *A Changing Village in the Alps*, by John Kippel Friedl (New York: Holt, Rinehart and Winston, 1974), is an anthropological study of a Swiss Valais village. Part of the "Life Nature Library Series," *The Mountains*, by Lorus J. Milne and Margery Milne (New York: Time Life Books, 1962), gives young adults and general audiences an illustrated introduction to mountains and mountain societies.

Crinoids (p. 58)

Crinoids and other echinoderms are discussed in two small books. The first, *Echinoderms*, by David Nichols (London: Hutchinson University Library, 1962), is a concise study of the structure, evolution, and some biological problems of the phylum. The second, *Starfishes and Their Relations*, by Ailsa M. Clark, was published in London by the British Museum (Natural History) in 1962 and is for more general audiences. H.B. Fell and Douglass Faulkner had a colorful article entitled "Crinoids and the Dawn of Deep-sea Research" in the May–June 1971 issue of *Fauna: The Zoological Magazine* (pp. 4–13). The "Ecology of Crinoids," also by Fell, can be found in *Physiology of Echinodermata* (New York: Interscience Publishers, 1966), a collection of essays by thirty-one experts in the field, edited by Richard A. Boolootian. Despite its age, *The Invertebrates: Echinodermata*, by Libbie Henrietta Hyman of the American Museum of Natural History (New York: McGraw-Hill Book Co., 1955), is still a useful work.

Deer and Wolves (p. 70)

L. David Mech provides additional, more scientific information in "Wolf-Pack Buffer Zones as Prey Reservoirs" (*Science*, October 1977, pp. 320–21) and "White-tailed Deer Migration and Its Role in Wolf Predation" (*Journal of Wildlife Management*, vol. 40, no. 3, pp. 429–41), coauthored by R. L. Hoskinson. "Population Trend and Winter Deer Consumption in a Minnesota Wolf Pack," by L. D. Mech, can be found in the *Proceedings of the 1975 Predation Symposium*, edited by R. L. Phillips and C. Jonkel (Missoula: University of Montana, 1977). *Man, Culture, and Animals: The Role of Animals on Human Ecological Adjustments* (Washington: AAAS, 1965), edited by A. Leeds and A. Vayda, has a section on "The Virginia White-tailed Deer in the Inter-tribal Buffer Zone." L. David Mech's *The Wolf: The Ecology and Behavior of an Endangered Species* (Garden City: Natural History Press, 1970) is for the scientist and the general reader. The author's rich field experiences, combined with the established data, make this a readable, well-documented volume. *Of Wolves and*

Men, by Barry Holstun Lopez (New York: Charles Scribner's Sons, 1978), concentrates more on the folklore and literature of the wolf in different cultures.

Flaherty and the Eskimo (p. 78)

Readers in search of more information about Robert Flaherty will find it in Flaherty's personal account of his life in the north, *My Eskimo Friends* (New York: Doubleday and Co., 1924), and in *The Innocent Eye: A Life of Robert J. Flaherty*, by Arthur Calder-Marshall (New York: Harcourt, Brace and World, 1963). *The Story of Comock the Eskimo*, edited by Edmund Carpenter (New York: Simon and Schuster, 1968), contains drawings by Noogooshoweetok, erroneously attributed in the book, including one of Flaherty setting up his camera. *People from Our Side*, by Peter Pitseolak and Dorothy Eber (Bloomington: Indiana University Press, 1977), is the story of Peter Pitseolak's life on south Baffin Island. It is illustrated with many of his own photographs; some were developed in an igloo. A selection of these can be seen in Dorothy Eber's "How It Really Was," which appeared in the February 1977 issue of *Natural History*. Pitseolak also wrote *Peter Pitseolak's Escape from Death* (Boston: Delacourte Seymore Lawrence, 1978), a colorful children's book edited by Dorothy Eber. *Life Among the Qualllunaat*, by Minnie Aodla Freeman (Edmonton: Hurtig Publishers, 1978), is a modern young Eskimo woman's account of her life and her work in the Department of Indian and Northern Affairs.

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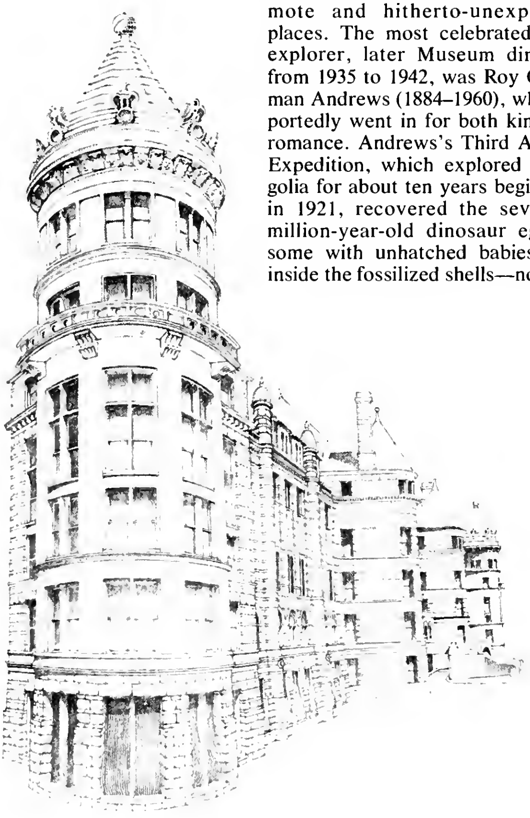
At the Museum



The American Museum of Natural History "was a great place for romance," a curator reminisces about the Museum of the twenties and thirties in Geoffrey Hellman's informal history, *Bankers, Bones, and Beetles* (Doubleday, 1968). The staffer was referring to affairs of the heart, but he could as easily have meant the romance of high adventure. The Museum—then as now—was sponsoring expeditions to remote and hitherto-unexplored places. The most celebrated staff explorer, later Museum director from 1935 to 1942, was Roy Chapman Andrews (1884–1960), who reportedly went in for both kinds of romance. Andrews's Third Asiatic Expedition, which explored Mongolia for about ten years beginning in 1921, recovered the seventy-million-year-old dinosaur eggs—some with unhatched babies still inside the fossilized shells—now on display on the Museum's fourth floor, near the Tyrannosaurus. On January 24, at 7:30 P.M. on the Auditorium's screen, Andrews and company will once again uncover the eggs in the Gobi Desert's sands. Alan Ternes, *Natural History*'s editor, will narrate **Expeditions,** a program of films from two Museum expeditions of the 1920s: Andrews's Third Central Asiatic Expedition, and a four-year photographic safari that Osa and Martin Johnson, professional adventurers and hunters, made across the East African veldt. Andrews's project was popularly labeled the Missing Link Expedition, although its army of paleontologists, paleobotanists, archeologists, zoologists, topographers, herpetologists, surgeons, geologists—including, briefly, Teilhard de Chardin—never did find any evidence of human prehistory. Andrews preferred to call his project the largest land expedition ever to leave the United States. It was also the first to explore Mongolia by car: Chapman had raised funds from the Phelps-Dodge Corporation, and the expedition films show "dependable Dodges" taking endless punishment in rocky desert passes. Andrews outfitted his crew with white sweaters emblazoned with TAE,

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The American Museum of Natural History will hold a public memorial service for Margaret Mead at 11:00 A.M. on Saturday, January 20, in the Auditorium.

---

equipped his open cars with dual white sidewall tires, and in prose out of Kipling described chasing Mongol bandits:

The trail was narrow and rocky, and I couldn't turn, but I knew that a Mongol pony never would stand against the charge of a motor. Opening the cut-out, I stepped on the accelerator, and the car rushed down the hill roaring like an airplane. The ponies went mad with fright.

Andrews used a supporting caravan of camels, which departed ahead of the cars, carrying gasoline, food, and equipment. The Museum's Photographic Collection possesses stills that show Andrews's men in their letter sweaters, as well as beautiful lines of patient camels spiraling up desert dunes. The collection, which advertises itself with a photo of Andrews—in breeches, boots, and flat-brimmed Army campaign hat—pointing forward across the Gobi, was also the beneficiary of Osa and Martin Johnson's 1928 photographic safari. (The Photographic Collection is open from 11:00 A.M. to 4:00 P.M. Transparencies can be rented and prints made on a prepayment basis.) Part of *Simba*, the Johnsons' cinematic record of their East African trip, will be shown during the January 24 program. Although the Johnsons were primarily interested in animals, the film does include a hilarious sequence of Osa Johnson, author of such romantic titles as *I Married Adventure*, roundly castigating a clumsy bearer. And at a watering hole, the Johnsons en-

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counter some beautiful Samburu girls, practically encased in elephant hair jewelry.

Outside the Ice Age Art show, which closes January 15, one enthusiastic visitor exclaimed, "This place should change its name to the American Museum of Natural History—*and* Art. It's giving the Metropolitan a run for its money." Down the street from the Museum, at Public School 9, Ice Age paintings—and the reasons they were made—were recently the subject of discussion between several teachers and Richard Lewis and other members of the **Touchstone Center.** Using the Museum as a resource, the teachers and the Touchstone staff, which includes a dancer, a poet, a sculptor, and a textile designer, have been developing curricula around themes drawn from the natural world. Touchstone aims to use the arts and what Lewis calls "the imaginative life" to teach city children about forests, mountains, and other natural phenomena they rarely see. This year, P.S. 9 students have speculated about why prehistoric people painted caves, have gone spelunking in Central Park, and have modeled their own caves out of clay and natural found objects. As an outgrowth of this school work, the Touchstone Players will present a theater piece by Lewis in Education Hall on January 13 and 14, at 1:00 and 3:00 P.M. Entitled "Cave," the work begins with the players indicating their heads—"In this cave, earth began"— and dramatically describes the origins of the natural world, using the cave as a symbol of the human imagination.

The Museum eagerly awaits the arrival of the art of **Pompeii A.D. 79.** Opening April 22, the show depicts life in this wealthy Roman resort city—buried and preserved by Vesuvius's eruption in the year 79—through its frescoes, mosaics, marble sculpture, glass, tools, pottery, cookware. A brochure describing how members and the public can obtain exhibition tickets is available at Museum information desks. This show has drawn crowds in London, Copenhagen, Boston, Chicago, and Dallas, and since only Museum members can order tickets in advance, this is a good time to join the American Museum of Natural History.

Ann Marie Cunningham

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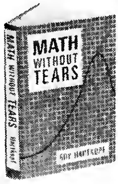

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Is high Diesel mileage a myth? Ask Robert J. O'Reilly, whose Mercedes-Benz 180D has rolled up 1,184,880 miles.

Is long Diesel life a myth? Ask Paul F. Dauer, whose Mercedes-Benz 260D is 41 years old – and still going strong.

Mercedes-Benz Diesel Search uncovers million-mile Diesel and 41-year-old Diesel, both still going strong.

It was a quest for hard, cold facts about the legendary Diesels of Mercedes-Benz – and "spectacular" describes the facts that were found.

Item: 10 Diesels with 7.5 million miles between them. Item: In this program, even a 797,855-mile Diesel was an also-ran.

Will that million-mile owner quit while he's ahead? His response: "I fully believe I'll be able to put another million miles on it."

Just how many miles can a Mercedes-Benz Diesel car run?

Just how many years can a Mercedes-Benz Diesel car last?

Despite the myths and tall tales, Mercedes-Benz knows that high mileage and long life – in a Diesel as in any car – depend not just on how well it's built but on careful service and upkeep. On how and where it's driven. And perhaps even on a little bit of luck.

But curiosity remained. And last May 29, Mercedes-Benz launched the Great Diesel Search in a unique quest for the facts.

Timely information

The Great Diesel Search was timed to coincide with the introduction of the most remarkable Diesel car in Mercedes-Benz history – the new 300SD Turbodiesel Sedan.

What better way to usher in this Mercedes-Benz "Diesel of the future" than to document Mercedes-Benz Diesel exploits of the recent past?

The Great Diesel Search lasted 30 days – too brief a time to comb the continent for all 130,000 Diesel cars Mercedes-Benz has sold here.

But time enough to locate a broad cross section. And from Texas to Pennsylvania, from New Mexico to Oregon, Diesel owners responded by the hundreds.

And now the facts are in, authenticated by an independent verifying body. And what these numbers say about the Mercedes-Benz Diesel speaks more eloquently than any words.

7,504,699-mile total

In the high-mileage category, for instance, the top ten Mercedes-Benz Diesel cars had travelled a total of *7,504,699* miles between them.

As the entries mounted, so did the mileage: a 190D with 812,332 miles gave way to a 170SD with 845,289 miles – a feat topped in turn by a 180D that had reached 847,970 miles.

But even this was ultimately not enough. Enter the 1968 220D driven in daily use by Mr. Edward Donaldson of Eugene, Oregon – a Diesel that within ten years had compiled 912,493 miles – the equivalent of two trips from the earth to the moon and back.

To top this achievement would demand a truly phenomenal mileage performer.

And the Great Diesel Search encountered just that: the phenomenal 1957 180D owned by Mr. Robert J. O'Reilly of Olympia, Washington.

Breaking the million-mile barrier

Exact mileage accumulated by the O'Reilly Diesel in its 21 years of service: *1,184,880*. The equivalent of about one hundred years of normal driving. The winner.

With this crowning achievement behind it, will Mr. O'Reilly now retire his 180D to a well-earned rest? Apparently not.

"I fully believe I'll be able to put another million miles on it," he estimates.

10 Diesels, 282 years

In the category of oldest Mercedes-Benz Diesels still registered and running, it was years and not miles that told the tale. The ten oldest cars entered in the Search represented an aggregate 282 years – almost three centuries' worth of dogged Diesel efficiency.

Eight of the top ten finalists dated from 1951 – Diesel cars already rolling along in regular service before almost half the Americans living today were even born.

The granddaddy of them all

But Mercedes-Benz had built the world's first production Diesel passenger car in 1936, 43 years ago. So not even a 27-year-old Diesel could rest on its seniority laurels.

And sure enough, the Great Diesel Search uncovered a car even older – 13 years older, to be precise: the 1938 260D landaulette owned by Mr. Paul F. Dauer of Chicago, Illinois. Imported to the U.S.A. in 1938, recorded as the 902nd Diesel passenger car ever sold by Mercedes-Benz, Mr. Dauer's 260D survives hale and hearty – not some museum piece but a licensed, functioning automobile. The winner.

The rewards...

Mr. O'Reilly with his million-mile Diesel and Mr. Dauer with his 41-year-old Diesel have both been honored by Mercedes-Benz in what seems the most fitting and most timely way.

Each has been awarded a new 300SD Turbodiesel Sedan.

Additionally, several runners-up have received expense-paid European vacations for two.

Four Diesel choices

The results of the Great Diesel Search showed that, for these owners, the promise of the Mercedes-Benz Diesel was kept.

And today's Mercedes-Benz Diesels are engineered and built with a sophistication and precision undreamed of in those pioneering years.

Now you can pick and choose between different Mercedes-Benz Diesel body styles and sizes... engine types... special equipment, from air conditioning to light alloy wheels. Scan the roster:

The new *300SD Turbodiesel* is a potent five-passenger Diesel that approaches a limousine level of comfort.

The *300CD Coupe* is an elegant 2+2 machine designed to compete on equal terms with any other limited-production two-door coupe extant.

The *300D Sedan* is a stirring performer doubling as a sensible five-passenger car, and comprehensively equipped.

The *240D Sedan* is a no-nonsense Diesel in the classic manner: 2.4-liter, 4-cylinder engine and manual 4-speed shift, standard.

See and drive a Diesel

Your local authorized Mercedes-Benz dealer will be glad to arrange a test drive. Call or visit him soon. It could be your first step toward winning the next Great Diesel Search.

Is vivid Diesel performance a myth? Meet the Mercedes-Benz 300SD Turbodiesel, the first performance car to run on diesel fuel.

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Authors

After a teaching stint at the University of California, Riverside, Canadian-born **Martin Daly** recently returned to his home country. An associate professor of psychology at McMaster University in Hamilton, Ontario, Daly's present research is on comparative social behavior, feeding ecology, and behavioral development in kangaroo rats. His gerbil article in this issue was based on his work at the desert oasis of Beni-Abbès, Algeria, during periods from 1972 to 1974. With Guggenheim Foundation support, he plans to study family violence from an evolutionary biological perspective.

John E. Reynolds III, shown here fondling a manatee skull, is a doctoral candidate at the University of Miami's Rosenstiel School of Marine and Atmospheric Sciences. Reynolds is concentrating on the structural and functional anatomy of the West Indian manatee's gastrointestinal tract. When he is not observing this endangered marine mammal, Reynolds tries to get in some weight lifting.

A professor of clinical pathology at the Medical College of Virginia, **Marvin J. Allison**'s special interest is medical anthropology. Allison, who made his first trip to South America in 1950, has since done numerous studies in Peru and Chile on the origins of various diseases and on human migrations. His rare book collection, knowledge of languages and linguistics, and enthusiasm for American archeology have proved handy tools in his investigations.

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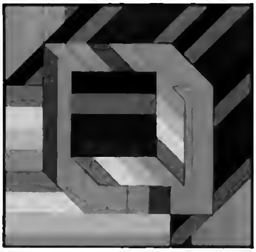

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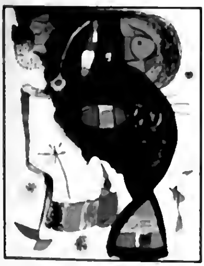

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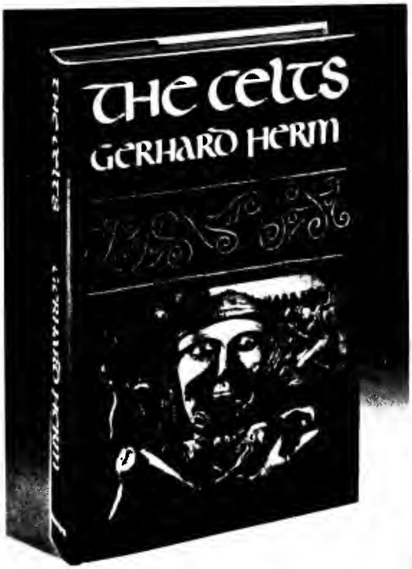

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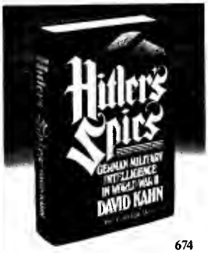

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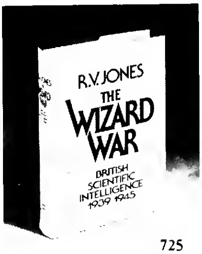

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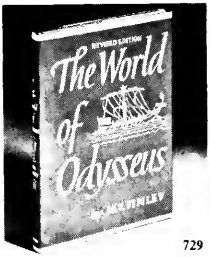

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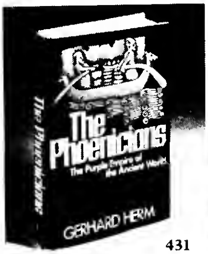

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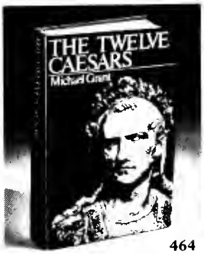

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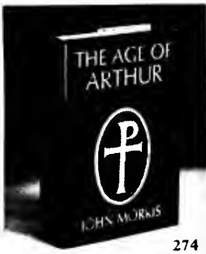

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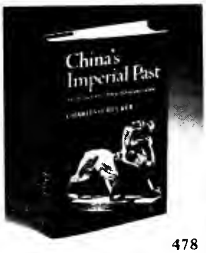

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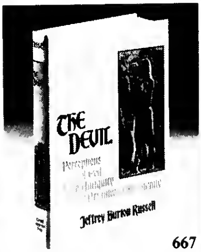

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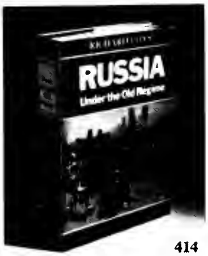

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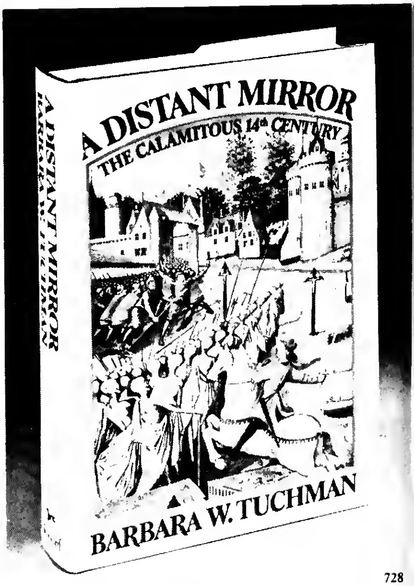

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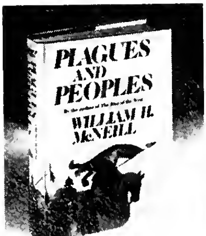

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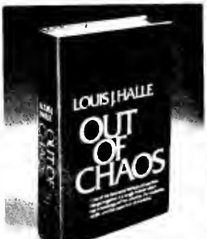

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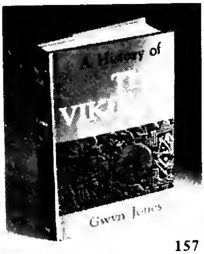

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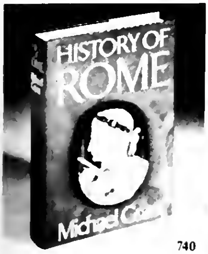

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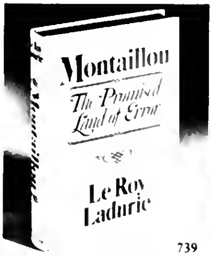

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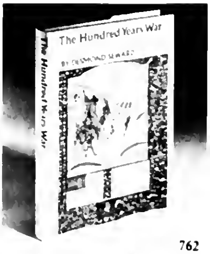

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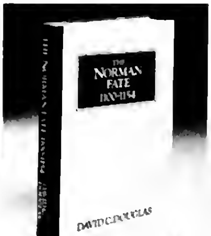

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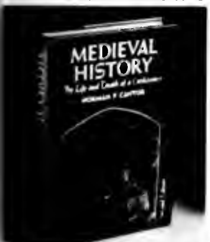

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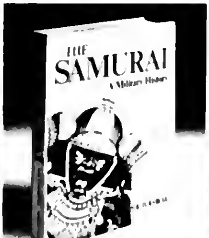

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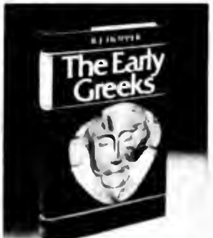

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Describing his fieldwork, **Robert Edward Cook,** assistant professor of biology at Harvard, writes, "I spend most of my summers watching violets grow and die in Concord, Massachusetts." Cook originally became a biologist because he wanted to study birds. But he was distracted by the problem of "trying to understand how individual plants interact with the environment." He has since looked into mortality and reproduction in wild violets, as well as growth and reproduction in plants of the genus *Chenopodium*. Cook has also written about the history of American ecology, notably the career of Ray Lindemann, a young Yale ecologist who died before his contributions could be fully recognized.

For ten years, microbiologist **Jerry L. Mosser** worked at taking bacteria apart to see what they are made of. Then, he writes, he "decided to try studying whole ones in their natural habitats for a change." To that end, in 1970 he joined the Yellowstone research project headed by coauthor Thomas D. Brock. Microbiological research, however, did not afford him the diversity he was looking for, so Mosser "decided to write about science instead of 'doing' it." Accordingly, he is now a science writer for the College of Agriculture and Life Sciences at the University of Wisconsin, Madison.

"Thinking like a microbe," is the way **Thomas D. Brock** characterizes his research on microorganisms in their natural environments. In order to do this work successfully, he adds, it has been necessary "to develop a large bag of tricks." These will doubtless be applied to his future research projects, which include the microbiology of Wisconsin lakes with special reference to blue-green algae and chemical changes induced by eutrophication. Brock, who took his degrees in microbiology at Ohio State University, is the E.B. Fred Professor of Natural Sciences at the University of Wisconsin, Madison. This is his second article for *Natural History* (see "Life in a Hot-Water Basin," December 1968).

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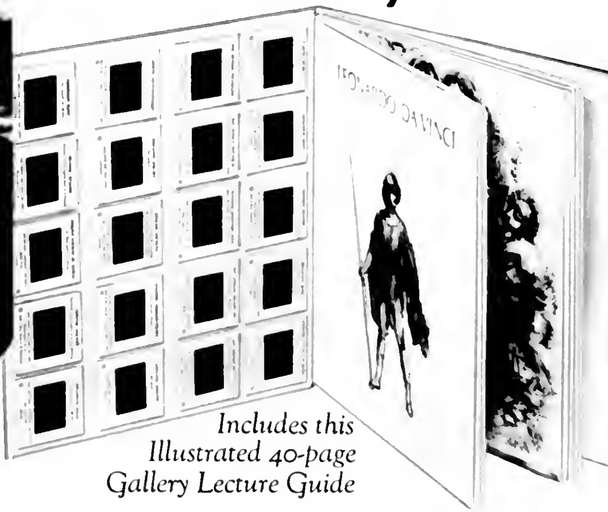

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Short People

by Thomas Gregor

As far as many societies —including America—are concerned, tall is beautiful and short is out of work

Despite its author's disclaimers, "Short People," Randy Newman's pop hit, reflects a remarkably widespread prejudice against short men. Yet so subtle is this bias in American society that I was never fully sensitive to it until I saw a similar pattern in a very different setting—among the Mehinaku, a tropical forest tribe of central Brazil.

My wife and I first visited the Mehinaku in 1967, when the tribe, which lives on a reservation nearly 175 miles from the nearest permanent Brazilian settlement, was little known. Reservation authorities had respected the Mehinaku land and way of life. The nearby rivers teemed with fish, the fields around the community produced abundant crops, and the villagers welcomed visitors—an ideal situation for an aspiring anthropologist.

In retrospect, my wife and I began to get an inkling of the Mehinaku interest in height and appearance on our first day in the area. On our arrival at the reservation post, we were greeted by several Mehinaku, who—after appraising our luggage and making rough estimates of the fishline, beads, and other gifts it contained—invited us to visit their community. After a three-hour canoe ride and an hour's walk, a large number of villagers escorted us to one of the five communal houses that make up the Mehinaku village of Jalapapuh, which means "the place of the ants."

Sensing that we were uncomfortable and uncertain how to conduct ourselves, the villagers tried to make us feel at home by generously providing typical hospitality. Our hosts tied our hammocks to the house poles, parents dispatched their children to fetch firewood and fresh water, and an older woman offered us a large portion of bread made from manioc flour, the staple of the villagers' diet.

Since we were unusual guests, the Mehinaku did not leave us to adjust to our surroundings; instead, some of them began their own ethnographic study. With my permission, two men systematically dismantled my portable typewriter and luggage. A cluster of children tied and untied my wife's shoelaces, while a circle of adults passed around my eyeglasses, which occasioned gasps of disbelief as each person tried to squint through the lenses. I repeatedly had to open my mouth to display fillings and bridgework to an understandably curious audience. And throughout this inspection, the Mehinaku asked us questions: "Where did you come from? How long will you stay? What gifts have you brought? How have you gotten so tall?"

That last question was unexpected, as was the questioners' admiring tone. From the villagers' perspective, however, we were tall. I am 6′ tall and my wife is 5′6″, while the average Mehinaku man is only 5′3½″. Subsequently, as we made our home in the village and tried to participate in Mehinaku life, I realized that my height was one of the few things in my favor. Even my strongest village advocates had to admit that as a would-be Mehinaku I was something of a failure. Long treks through the forest to hunt monkeys or birds hardly seemed to faze my companions but left me lacerated with thorns, covered with ticks, and utterly exhausted. And my efforts to shoot a fish with a bow and arrow while standing on the prow of a canoe became a permanent joke, publicly imitated by the younger boys. But at least I was tall.

To be highly regarded a Mehinaku must be physically attractive, and to be attractive, a man must be tall. Such a man is respectfully described as *wekepei*. He is said to be tough in his bearing, a powerful wrestler, a successful hunter and fisherman, and a person of political importance. Ideally, all village chiefs are tall. In fact, the present Mehinaku chief is the tallest man in the village. In his regular public speeches he tells of a golden age when all the villagers worked hard, disease was nonexistent, and men were taller and more heavily muscled than today.

Very short men are referred to—behind their backs—as *peritsi*. This term has a derisive, mocking quality, and it is seldom applied to an unfortunate villager without a sneer or a nasty laugh. A *peritsi* is not only short; he is ridiculously short. He has only himself to blame for his condition, however, for being a *peritsi* is not only a physical shortcoming but also a moral failing. Growing up tall and strong is not viewed as a roll of the genetic dice but can be insured by following the rules of adolescent seclusion. During this period a young man takes medicine, winds cotton ligatures tightly around his calves, and avoids sexual relations. This last prohibition is particularly important since sexual intercourse is regarded as weakening and likely to stunt growth. *Peritsi* rhymes with the word for penis (*itsi*); in derisive jokes and puns the *peritsi* is a per-

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son whose *itsi* is "too hungry" for intercourse. Lacking the self-discipline to follow the rules of adolescent seclusion, the *peritsi* winds up ridiculously small, and for this he pays a high price. Short men, for example, have a hard time finding friends much taller than themselves. Awana, a tall young man and a wrestling champion of the village, told me, "I don't want a *peritsi* for a friend. They don't make good wrestlers. I don't want people to see me walking with them. Everyone laughs at a *peritsi*."

Indeed, perhaps the most serious liability of the extremely short man is his failure to inspire respect in other men. Itsa, one of the shortest men of the village, has apparently accepted the villagers' disrespect and made himself a kind of village fool and jester. When he wrestles, the men shout mock advice at him from the bench in front of the men's house, and he exaggerates the style of the more successful wrestlers to earn their laughter. He is also continually teased about his usually unsuccessful amorous exploits.

Short men are not only rejected by their own sex; they are also unattractive to women and prospective parents-in-law. No one wants a *peritsi* for a son-in-law. One of the shorter villagers informed me, "Once I went into Wairuma's house to speak to her. Her father saw me and got very angry: 'Get out of here! I want a champion wrestler for my daughter, not a *peritsi* like you!' "

Kama is the shortest man in the village, shorter than some of the women. He is abused behind his back in many ways. Some men conduct affairs with his wife and show very little concern about his knowledge of liaisons. They do not openly flirt with the woman when her husband is present, but they make passes at her when they think he is away. The villagers explain the adulterers' boldness in terms of Kama's stature, for a short man is not worthy of fear and respect. Judging by the comments of some men, Kama's size justifies their taking advantage of him. Not only can others tease him and safely have sexual relations with his wife but as a *peritsi* he deserves such treatment.

A villager's height correlates closely with the number of girlfriends he is likely to have, the frequency of his sponsorship or participation in village rituals, and his wealth. Among the sexually free Mehinaku, the number of a man's extramarital sexual engagements is a particularly significant measure of the effect of his height. In our village, the three tallest men had as many affairs as the seven shortest men, even though their average estimated ages were identical (thirty-seven).

A man who has many girlfriends, who is actively engaged in the ritual life of the community, who is rich, and who is a chief is generally regarded as a solid citizen. He is particularly likely to be called an *awujitsi*, a term of praise for those who are sociable and have earned the community's respect. The individual who only minimally participates in community affairs, however, is more than likely to be viewed as asocial, a "trash yard man" (*miyeipyenuwanti*). The three villagers acknowledged by most of their fellows to be trash yard men were among the shortest in the community.

Still, for the Mehinaku, height is only one of a number of important determinants of social participation, and not every short man is doomed to be openly teased by his fellows, have few girlfriends, and be labeled a trash yard man. Tana, for example, was only 5′¼″, the second shortest man in the village, yet he had no less than six simultaneous extramarital affairs. And Itsitya, also very short, was greatly feared as a powerful witch before his untimely death in 1971 at the hands of some of the villagers. Given the prevailing bias toward height, however, a short man is rarely accepted among his fellows on the same basis as men fortunate enough to be tall.

In an effort to discover the generality of the preference for tall men, I invested some research time in the Human Relations Area Files, a nationwide data-filing system that

Height and Social Participation of Adult Mehinaku Men

Height	*Age*	*Number of Girlfriends*	*Rich or Poor*	*Rituals Sponsored*	*Rituals Participated in*	*Chief or Non-Chief*
5′9¼″	55	6	R	1	1	C
5′5″	23	10	R	1	3	C
5′4¼″	35	7	R	1	3	N
5′4¼″	28	7	R	2	1	C
5′4¼″	28	6	?	1	2	N
5′4¼″	45	3	?	0	2	N
5′4¼″	31	3	P	1	0	N
5′3¾″	45	4	?	0	0	N
5′3¾″	45	3	P	1	0	N
5′3¾″	36	2	P	0	0	N
5′3″	41	4	?	0	1	C
5′2¾″	41	2	P	0	1	N
5′¾″	45	3	P	0	0	N
5′¼″	31	6	P	0	1	N
4′11¾″	23	3	P	0	0	N

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"Some of my friends seem to think that anybody who works for an oil company likes dead birds and dirty beaches," says Gulf Drilling Superintendent Bob Eslinger.

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helps retrieve information on a particular topic from ethnographic descriptions of many societies. I found that many cultures have a definite preference for tall men. The Trobriand Islanders of the Pacific, for example, admire "a slim, straight, tall body"; the Timbira of Brazil prefer their men on the tall side; and our own Navajo traditionally feed their children salt to insure a good adult height. In no case have I found a preference for short men, although Robert Lowie reports that the Crow speak disparagingly of men who are "too tall" (about 6'2" and over) and Colin Turnbull writes that "my Pygmy informants pitied me for my height, which made me so clumsy."

Rituals allow Mehinaku men to show off ornaments, body paint, good height, and physique. Western dress is newly fashionable.

Although many societies other than the Mehinaku favor tall men, only a few rival the Mehinaku in the strength of their distaste for short people. Among these, we must surely count modern America. Especially during courtship, Americans become acutely aware of the importance of being tall, but actually at any time, stature may influence our self-esteem, the opinion of others, and even our chances of economic and social success. "American society," writes sociologist Saul Feldman, "is a society with a heightist premise: to be tall is to be good, and to be short is to be stigmatized."

Feldman points out that a rich vocabulary of abuse impugns the human status of the short man: he is derided as "puny," "sawed-off," a "shorty," a "pipsqueak," a "shrimp," or a "runt." This attitude, Feldman argues, finds its way into our ordinary speech, for

when we degrade people we "put them down" or "belittle them". . . . The ideal man is viewed as *tall*, dark and handsome. Impractical people are "shortsighted," dishonest cashiers "shortchange" customers, losers get the "short end of the stick," electrical failures are known as "short circuits," and individuals with little money . . . will state . . . "I'm short." A few years ago, a well-known politician spoke at a midwest liberal arts college and referred to a former head of the Federal Bureau of Investigation as "that short little pervert in Washington." It is rare that one hears of tall perverts for in many respects, just to be short is to be a "pervert."

The prejudice against short men goes well beyond pejoratives to include economic discrimination. Arbitrary height requirements bar the short man from certain jobs, notably in police and fire departments and in the armed forces. In the United States Army, Air Force, and Navy the present cut-off height is 5', while the Marines, unaccountably, accept applicants who are 4'11". For police and firemen, height requirements are commonly more stringent. Feldman notes that in Washington, D.C., for example, all

Thomas Gregor

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police and firemen must be at least 5'7", and in the state of Washington, police and firemen under 5'8" are ineligible for pension coverage. As arbitrary as these rules may sound, the "heightist" nature of our society provides a marginal justification, at least in the case of policemen. A study in Atlanta shows that although they are as efficient as their taller colleagues, short policemen are more likely to be assaulted.

Even when not a formal part of the job description, unreasonable height requirements may be present as an unspoken prejudice against the short man. Feldman cites a study, originally appearing in the *Wall Street Journal*, that reveals some of the hidden biases:

"David Kurtz, marketing professor at Eastern Michigan University, asked 140 recruiters to make a hypothetical hiring choice between two equally qualified applicants—one 6'1" and the other 5'5"—for a sales job. Seventy-two percent 'hired' the tall one, 27 percent expressed no preference, and 1 percent chose the short one."

Let a short man break into a profession despite the odds, and he still faces economic discrimination. Leland Deck of the University of Pittsburgh conducted a three-year study of recent university graduates. Deck concluded that not only does "the great American six-footer" get the choice job, but in his first year he is paid better than 10 percent more than his shorter classmates. This finding is all the more remarkable given that many of the jobs in Deck's sample were in fields, such as college teaching, that have little to do with physical appearance or abilities. Deck's findings suggest that economic prejudice against women, Orientals, Mexican-Americans, and other groups who are generally shorter than most American men may be partly explained as height prejudice, rather than simply ethnic and sex prejudice. Thus, "women who are 5'7" make the same money as 5'7" men."

More pervasive than economic discrimination, and perhaps even more damaging, is the prejudice against short men that is built into our culture and our attitudes toward others. Consider psychologist Paul Wilson's elegantly simple experiment, relating our perception of a person's height to his position in a hierarchy. Wilson introduced the same visitor to one of his classes as "Mr. England, a student of psychology," and to another class as "Professor England from Cambridge." Later the students were asked to estimate England's height. To the average student, the visitor grew nearly two and a half inches when he was introduced as Professor England. Wilson's experiment has been replicated by a number of other investigators who also show that persons from racial and ethnic minority groups are often seen as shorter than they actually are.

Finally, for the short man, no experiment in social psychology is necessary to convince him of the stigma of his height. Teased in school by his taller classmates, lined up in "size place" by his teachers, and rejected in courtship by taller women, he quickly gets the message. Should he fail to understand it, it will be repeated in many guises. Once again, according to Saul Feldman:

> Games such as basketball glorify height. Few baseball or football players are short. Boxing interest is not among flyweights or bantamweights but among taller middleweights and heavyweights. The one sport associated with short people is horse racing . . . however, the short jockey is given second place to a horse . . . and despite the great popularity of horse racing, a jockey's face has never appeared on a bubblegum card.
>
> In the movies the short actor is rarely the romantic lead. The average American cannot identify with the hero unless he rides "tall in the saddle." Thus the short actor is reduced to playing the buffoon (Mickey Rooney), the arch-villain (Peter Lorre), or the small tough guy with the big Napoleon complex (Edward G. Robinson).

Like a short Mehinaku, a short American man confronts prejudice in popular attitudes, in his dealings with the opposite sex, and in his economic activities. A possible reason for the widespread prejudice against short men is that a preference for tall people is part of a tendency to value all large things. Certainly both the Mehinaku and Americans are impressed by bigness—whether in a house, a car, a canoe, a basket, or a man. And numerous experiments in social psychology back up the association of size and value among American and other Western subjects. This equation would probably not be foreign to people in other societies since children everywhere are socialized into an adult world of oversized people and objects. Tall adults control a child's world, and children aspire to their position; thus, height and size should be valued by many peoples.

A second origin of the preference for tall men can be found in political relationships. Although in no known society is leadership allotted primarily on the basis of physical size or strength, a tall, well-built man will no doubt have the edge over a shorter competitor. Among the Mehinaku, a tall man has a clear political advantage over his shorter rivals. He is *kaukapapai*—worthy of fear and respect—while they are merely laughable. Americans may follow the same pattern. According to some very tall men, such as 6'9" Michael Crichton, author of the *Andromeda Strain*, height is a definite advantage: "You go into a room or meeting and you immediately become a commanding figure. People pay attention to you. Of course, if you say a lot of stupid things, they'll stop paying attention to you. But at least you have that kind of early advantage constantly working for you." American presidential politics provides further evidence of the political impact of height. In all but three of the presidential elections held since 1900, the taller candidate has won.

For short Americans, if not for short Mehinaku, there is one ray of hope. Over the long term, American society has moved toward assigning an individual's position in the community on the basis of ability, rather than on irrelevant qualities such as sex, race, or ethnic background. Not only is discrimination on the basis of these characteristics usually unlawful, it is often bad business in an economy that values skills and job performance. For the moment, however, the bias that confronts short Americans is subtle, and progress is likely to be slow. Randy Newman may have written "Short People" as a spoof of prejudice, but it is an all-too-accurate reflection of the attitudes of our society.

Six-footer Thomas Gregor is associate professor of anthropology at Vanderbilt University.

Total Eclipse

by Thomas D. Nicholson

The last total solar eclipse of this century to be seen from anywhere in the contiguous forty-eight states will occur on the morning of Sunday, February 26, 1979. Not until 2017 will the moon's shadow again pass across the United States, except for Alaska in 1990 and Hawaii in 1991. For many in the United States and Canada, the event on the 26th will therefore be the opportunity of a lifetime to see the thrilling spectacle that results when the moon completely covers the bright disk of the sun.

Apart from the relatively narrow path in the northwestern United States and central Canada where the total eclipse can be seen, a partial solar eclipse will be visible throughout the entire continent of North America (with the exception of the western part of Alaska). Except for viewers in the southern part of Florida, more than half the sun's diameter will be covered by the moon at mid-eclipse, and for much of the continent, the moon will cover more than 90 percent of the sun's bright area. Thus, even though most Americans will not see the total eclipse, everyone will have an opportunity to observe the dark moon as it encroaches on the sun. As always, of course, safe methods should be used by everyone determined to see what is happening.

The eclipse this month brings with it both good and bad news for those who wish to see the events of totality from within the moon's shadow path. The good news is that the nearly 200-mile-wide path that the shadow crosses includes a great many large population centers that are easy to reach and have good accommodations for travelers. The vistas should be superb in the scenic northwest, where the sun will be low during total eclipse.

The bad news is the weather. In general, prospects are not good anywhere within the total eclipse path. Along the Pacific coast, and in most of Washington and Oregon, the chances of having sufficiently clear skies are less than one in four. The odds are somewhat better toward the east, partly because the sun is higher during the eclipse and partly because climatic conditions improve. Within the continental United States, Montana and North Dakota offer the best climatic bet, but Manitoba, in Canada, is even better, with about a 50 percent chance of seeing the eclipse. The trade-off for improved weather, however, will be lower temperatures. As the eclipse path moves east, it also moves north, into the northern plains where temperatures of near zero Fahrenheit or below are not uncommon, especially during the clear weather conditions one would hope for.

The best hedge against uncertain weather conditions will be mobility, the ability to shift one's location rapidly as soon as more reliable weather data become available and weather conditions become apparent. Many observers are making plans to do just that.

For the adventuresome and courageous (and, with respect to weather, the fortunate) who travel to the total eclipse zone, the rewards will be impressive. Even those who have already witnessed a total solar eclipse will probably be thrilled anew. Nothing can prepare one for the pale, eerie light that drops swiftly just before the sun is completely covered, or for the stillness sensed by animals, as well as humans, that seems to settle on the earth. Then the events of totality begin: the flashes of Baily's beads, the crimson of the ring that surrounds the dark moon, the shimmering bluish white of the coronal streamers, the possible scarlet of a flamelike prominence standing above the sun, the planets and stars nearby in the darkened daylight. The approach of the moon's shadow and its swift escape to the east are unforgettable.

If the skies are clear on that Sunday morning, even the partial eclipse will be obvious to everyone in North America. If the skies are overcast, one might not know an eclipse is taking place at all. But where the sun is visible, the presence of the moon crossing in front of it will be evident. And those are the circumstances in which one should observe the standard precaution: *Never look directly at the sun without adequate protection for the eyes.*

Do not, however, misunderstand the basis for the caution, as so many persons seem to have done in recent years. There is nothing unusually harmful about the sun during an eclipse and no reason to walk around with your eyes cast down.

There is no reason why you should not view the eclipse if you want to, provided you take precautions to protect your eyes. One of the best ways is to project the image of the sun onto a white surface by means of a small telescope, a binocular lens, or even a small pinhole in a piece of cardboard. Another way is to use an adequate filter, such as a 5.0 neutral density optical filter. Or, if there is time, you can prepare a filter by opening an unexposed roll of black and white film in daylight and then fully developing the film. Two thicknesses of developed film over the eyes will make a suitably protective filter. Sunglasses, however, do not afford adequate protection. Nor is it safe to use so-called smoked glass or colored glass from a soda, beer, or other type of bottle. When the sun is *completely* covered by the moon during a *total* eclipse, it is perfectly safe to look directly without filters of any kind.

Thomas D. Nicholson directs the American Museum of Natural History.

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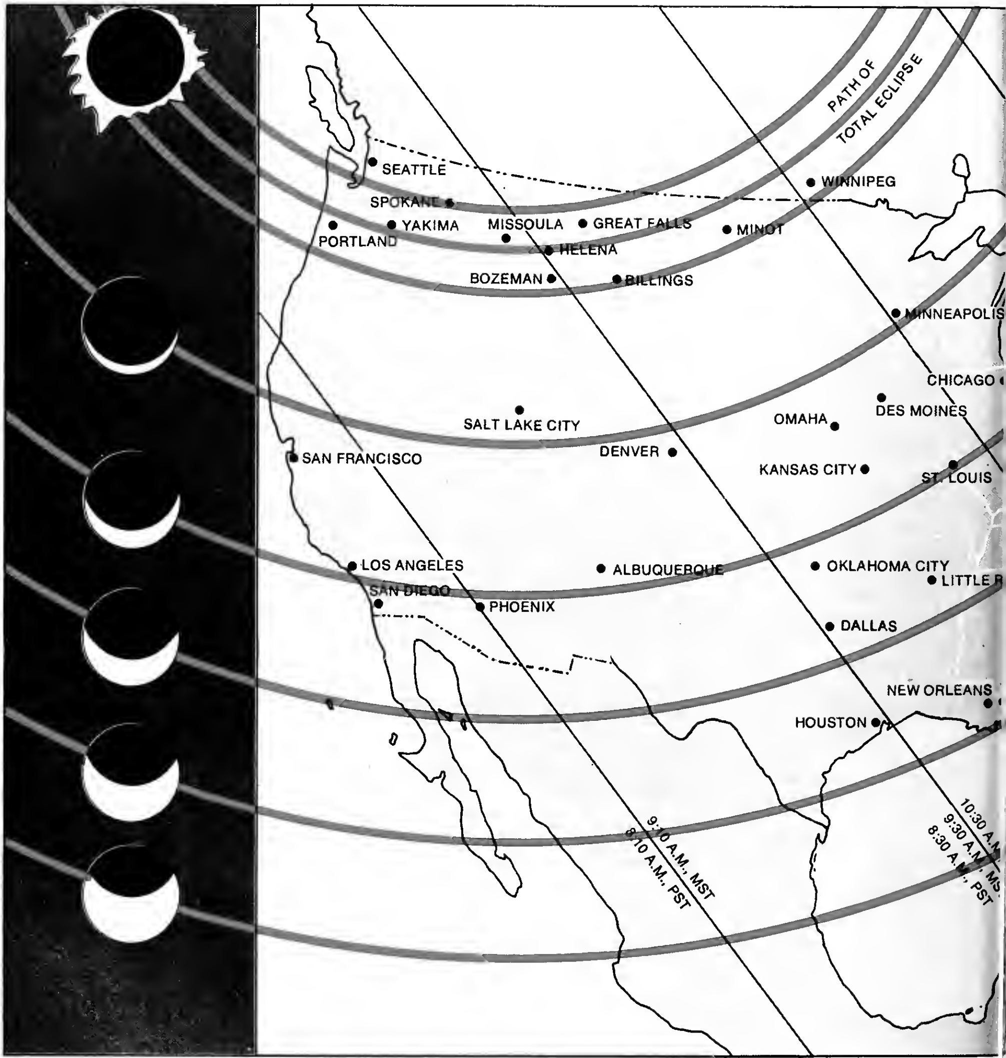


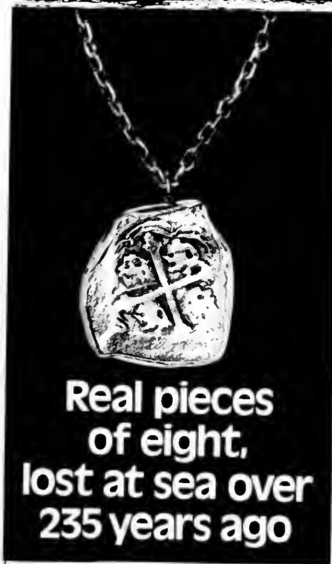
The path of the total eclipse is shown by the band crossing the northwestern United States and central Canada. The duration of the total eclipse, during which the sun is completely covered by the moon, is greatest along the central line in this path and falls off sharply near the path's northern and southern edges. On the center line at the Pacific coast, the duration will be about 2 minutes and 16 seconds; it increases to about 2 minutes and 52 seconds just east of Lake Winnipeg in Canada.

Outside the path of the total eclipse, a partial solar eclipse will take place throughout the United States and Canada, except for Hawaii and western Alaska. The magnitude of the partial eclipse (the portion of the sun's diameter covered by the moon at mid-eclipse) decreases with distance from the total eclipse path but is never less than 50 percent, except in southern Florida. The curves running approximately east–west on the map, and nearly parallel to the total eclipse path, show where the moon covers 90, 80, 70, 60, and 50 percent of the sun's diameter, respectively.

The eclipse occurs shortly after sunrise along the Pacific coast, and progressively later toward the east, where the sun is higher and the time later. In addition, the moon's shadow moves east along the earth, which causes the eclipse to move from west to east. The time of the eclipse at any given locality may be estimated from the time of mid-eclipse, shown by the lines running up and down (or nearly so) on the map, taking account of the correct time zone for your locality. The eclipse will begin about 75 minutes earlier and end 75 minutes later than the time of mid-eclipse, in central and eastern United States and Canada. In the mountain and coastal

states and the eastern half of Canada, adding or subtracting 70 minutes will yield times correct to within 2 to 3 minutes.

It should be especially noted that the time of mid-eclipse shown on the map is *not* the time of maximum eclipse, or of mid-totality, which occurs several minutes *earlier*. For accurate predictions of the times and circumstances at any given locality, readers should refer to U.S. Naval Observatory Circular No. 157, *Total Solar Eclipse of 26 February 1979*, Alan D. Fiala and Marie R. Lukac, U.S. Naval Observatory, Washington, D.C. 20390.



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Faster Than the Speed of Light?

Galactic objects whose seeming velocities defy accepted laws of physics demand an explanation

What goes faster than a speeding express train or a flying bullet? Superman and many things. What goes faster than the speed of light? According to the well-established laws of physics, nothing. The laws of relativity and many experiments in nuclear physics lead to the strong conclusion that nothing in this universe can exceed the speed of light. Things either travel intrinsically at that speed, as do light waves and radio waves, or they are particles that become indefinitely more massive as they approach the speed of light, which prevents even the most powerful of accelerators from ever pushing them to that limit.

So it was with amazement that radio astronomers recently observed two objects flying out of the heart of a distant galaxy, going in opposite directions at what seemed to be about ten times the speed of light. The scientists almost hoped the observation was a bizarre illusion. But then the same event occurred in another galaxy and another and another. Finally, in 1974, one of these objects, the radio galaxy known as 3C 120, fired off a second set of things at about eight times the speed of light. One of the most basic tenets of modern science was challenged.

There have been suggestions that particles might exist that go faster than the speed of light. Called tachyons, these particles have been hypothesized on the basis that the mathematical symmetries in the equations of relativity permit such entities. They would be strange in that they could only go *faster* than the speed of light. As they lost speed, they would become ever more difficult to decelerate, so that they could never be slowed down to the velocity of light.

There is no evidence whatsoever that such particles exist. Preliminary searches for evidence of them among the cosmic rays have yielded negative results. But then no one really knows how to design a device that could detect tachyons. In any case, the objects actually observed radiate similarly to other strong sources of radio emissions in galaxies, suggesting that they are made of normal matter. In the best tradition of science, the problem posed is to use known physics to explain the phenomenon of objects that apparently travel faster than the speed of light, or superluminally.

Before looking at possible explanations, one needs to know the nature of the actual observations. Things flying faster than the speed of light are not detected with run-of-the-mill radiotelescopes. The technique used, one of the triumphs of modern astronomy, is known as very long base line radio interferometry, or VLBI (see "Deep in the Heart of the Milky Way," *Natural History*, October 1978). In this technique two or more radiotelescopes separated by thousands of miles or even by continents simultaneously observe a radio-wave-emitting object in the sky. The signals they receive are recorded on magnetic tape with a precise time synchronization provided by atomic clocks at each telescope. In the important observations of 3C 120, for example, radiotelescopes at Green Bank, West Virginia; Fort Davis, Texas; and Owens Valley, California, were used. The magnetic tapes are then played synchronously into a small computer that combines the signals as though the telescopes had been connected together electrically at the time of the observations.

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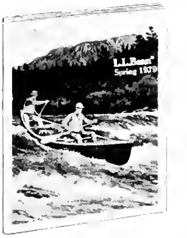

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There is a catch, however—because the "lens" of the telescope is not complete, it does not give a well-defined image. Instead, it tells us some of the aspects of the image, such as the existence of certain fine details, but not what the object truly looks like. The system is nevertheless particularly sensitive to the presence of two small objects of similar brightness. It can tell us that such a pair exists, how the duo is oriented in the sky, and what the angular separation between the two components is. This is just the kind of observation that led to the discovery of the superluminal objects.

As one after another of the "compact" radio sources, that is, those with very small, bright radio-emitting areas, was looked at with the VLBI system, their cores were found to contain two small bright objects. Subsequent follow-up observations again showed two bright objects, but more widely separated. Using the distance to the radio source, indicated by its red shift, a velocity could be computed for the speed at which the bright objects were moving apart. It turned out to be superluminal. For example, the quasar 3C 345 showed the presence of two objects with a separation that grew from about 0.5 thousandths of an arc second to about 1.8 thousandths of an arc second between the years 1969 and 1977. The inferred velocity is 4.2 times the velocity of light. However, the observing technique cannot tell us any detail about the objects or, with any certainty, whether there are other, fainter objects present.

So far, about half the compact radio sources that have been looked at with VLBI have shown superluminal expansions, with separation velocities ranging from 4.2 to 10 times the velocity of light. In every source, the velocity seems to remain constant. No examples of radio sources moving toward each other have been observed. Radio galaxy 3C 120 has shown at least two and maybe three pairs of superluminal objects. In several cases there has been an abrupt brightening of the radio emission from the source just as the two bright objects at the core started their separation, suggesting that the phenomenon may be caused by an explosive event.

Can we explain all this in a plausible way without being forced to accept the existence of superluminal velocities? Many astronomers are trying. The first possibility to consider is that the superluminal motions are misleading and no object is truly moving at the apparently observed speeds. Models along this line are easy to imagine. For example, if you shine a flashlight on a wall and then turn it quickly, the spot of light will move across the wall much faster than the flashlight is moving, but the spot is not an object. No object is moving as quickly as the light.

In like manner, it may be that what we are seeing with our radiotelescopes is, in fact, a rotating beam of particles or some other source of energy sweeping across interstellar clouds in a galaxy. However, there are strong objections to this hypothesis. The speed of the observed bright objects seems constant; if the source from which they are emitted was rotating, we would perceive the objects as moving at variable speeds. One might also expect to find apparent contractions as well as expansions between the radio sources but they have not been seen.

A very popular theory that probably does play some role in the phenomenon is the so-called Christmas tree model. In this picture, the radio galaxy consists of a number of small regions of radio emissions that turn on and off randomly, like the twinkling lights of a Christmas tree. According to this proposal, the apparent motions result from some of these "lights" turning on while others turn off; when we observe on different occasions, we are not actually seeing the same two objects each time, but a different pair on each successive viewing. Indeed, Canadian radio astronomers have seen some radio galaxies that do twinkle in this fashion. But in the Christmas tree model, as in others, apparent contractions as well as expansions should be seen

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when two close-together points light up after two far-apart points have been shining. But no contraction has ever been observed. Furthermore, observations of superluminal radio sources at closely spaced time intervals show the two sources of radiation separating at a continuous, steady rate, not in jumps. So much for the Christmas tree model as an explanation of the superluminal phenomenon.

A theory that does work, being consistent with all the existing data, is a modified version of the so-called light-echo hypothesis. In the year 1901, a star exploded as a nova in the constellation Perseus. Coincidentally, this nova was very close to a cloud of stellar dust, material that is usually seen silhouetted against a starry background but which is actually quite reflective. When the expanding shell of light waves from the nova encountered this dust cloud, the light of the nova was reflected. On the earth this was seen long after the nova explosion because of the indirect route taken by the light and, of course, the first light echoes to arrive at the earth came from those parts of the reflecting cloud closest to the nova. The overall result was the appearance of an expanding ring of light, moving outward from the star at the speed of light. This meant that the two opposite points on the ring seemed to move away from each other at twice the speed of light.

David Lynden-Bell of Cambridge University has shown how a modification of this simple phenomenon can explain the superluminal velocities. He proposes that an object in the nucleus of a galaxy violently emits two high-energy entities in opposite directions at the speed of light. This galactic object is probably the same one that produces the high energy of quasars, and may be a black hole many thousands of times the mass of the sun into which matter is falling, releasing huge quantities of energy in the process. The two ejected energy entities may be clouds of highly energetic nuclear particles or they could be waves of electromagnetic energy of sufficient intensity to accelerate any charged particles they encounter to nearly the speed of light. With each of these possibilities—clouds or waves—strong radio emissions will be sent out. Thus two small regions of intense radio emission are created.

Now if the two ejected energy bodies fly off in directions exactly perpendicular to our line of sight, we will see the emitting regions separating at exactly twice the velocity of light as in Nova Persei. But if the axis of the ejection is not perpendicular to our line of sight, the Doppler effect becomes important and the geometry of the situation causes the apparent velocity of separation to be even greater than twice the velocity of light.

The radio waves from the more distant of the two bodies have to travel a greater distance to the earth than those from the nearer body. Since they are both moving away from the nucleus of the galaxy at the same speed, the radiation we receive at any given instant will have left the farther body earlier than the radiation from the nearer one. We will thus perceive an apparent but illusory asymmetry in the positions and apparent velocities of each of the radiating entities. The near one will seem to move at enormous speed, while the far one will apparently move much more slowly. In working out the time delays associated with the angle of ejection and our line of sight, we find that when the angle is 30°, we should see an apparent separation velocity of four times the speed of light, as in 3C 120. Lynden-Bell has shown that all four of the known superluminal expansions are consistent with this picture.

For the present, this explanation does extremely well. It makes an important prediction: when we see these objects in detail, something very long base line radio interferometry should soon achieve, we will see the two emitting regions moving outward in precisely the asymmetric manner this model predicts. The laws of physics therefore seem secure for the time being.

There is, however, a final twist to this story. In the case of 3C 120, the galaxy involved can be photographed and its angle of ejection deduced. In another case, that of the quasar 3C 273, there are enough VLBI observations to give a fairly clear picture of the galaxy, and three asymmetrically placed bright spots are indeed found, one of which is conjectured to be the object that ejects the other two. In these cases, then, there is an indirect but still tantalizing way to determine the angle between the axis of ejection and the line of sight independent of Lynden-Bell's model. This gives us new information that allows us to determine the distance to the object without having to depend on the Doppler effect. The two radio galaxies mentioned above provide the same surprising results: they are half as far away as the distances given by the currently accepted values for the rate of expansion of the universe. The implication is that there is an error in the other techniques for measuring distances to galaxies. The universe may be smaller and younger than we have believed, more like 10 billion than 20 billion years old. The superluminal galactic "Roman candles," one way or another, are thus leading us to the answers to some of our fondest and most profound questions.

Radioastronomer Frank D. Drake is the Goldwin Smith Professor of astronomy at Cornell University and director of the National Astronomy and Ionosphere Center operated by the university for the National Science Foundation.

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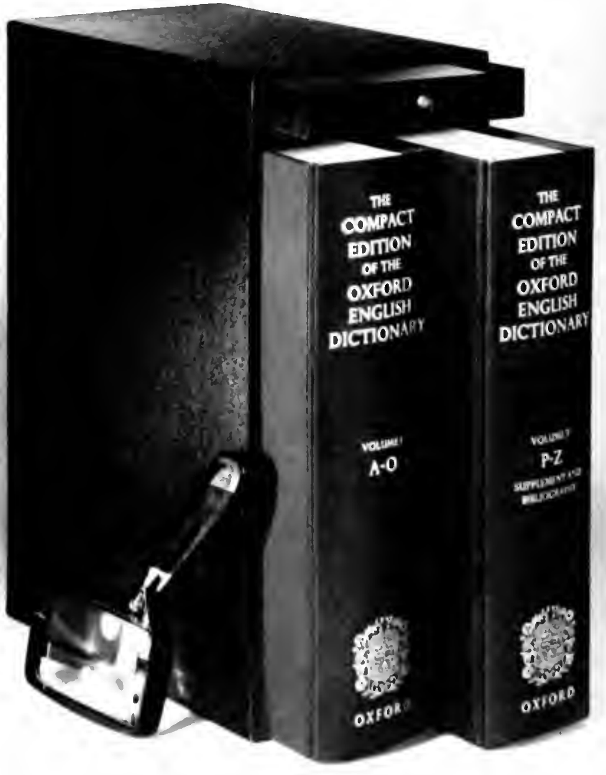

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Wide Hats and Narrow Minds

May Einstein's brain rest in peace inside a Mason jar in Wichita

In 1861, from February to June, the ghost of Baron Georges Cuvier haunted the Anthropological Society of Paris. The great Cuvier, Aristotle of French biology (an immodest designation from which he did not shrink), died in 1832, but the physical vault of his spirit lived on as Paul Broca and Louis Pierre Gratiolet squared off to debate whether or not the size of a brain has anything to do with the intelligence of its bearer.

In the opening round, Gratiolet dared to argue that the best and brightest could not be recognized by their big heads. (Gratiolet, a confirmed monarchist, was no egalitarian. He merely sought other measures to affirm the superiority of white European males.) Broca, founder of the Anthropological Society and the world's greatest craniometrician, or head measurer, replied that "study of the brains of human races would lose most of its interest and utility" if variation in size counted for nothing. Why, he asked, had anthropologists spent so much time measuring heads if the results had no bearing upon what he regarded as the most important question of all—the relative worth of different peoples:

Among the questions heretofore discussed within the Anthropological Society, none is equal in interest and importance to the question before us now. . . . The great importance of

Baron Georges Cuvier

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craniology has struck anthropologists with such force that many among us have neglected the other parts of our science in order to devote ourselves almost exclusively to the study of skulls. . . . In such data, we hope to find some information relevant to the intellectual value of the various human races.

Broca and Gratiolet battled for five months and through nearly 200 pages of the published bulletin. Tempers flared. In the heat of battle, one of Broca's lieutenants struck the lowest blow of all: "I have noticed for a long time that, in general, those who deny the intellectual importance of the brain's volume have small heads." In the end, Broca won, hands down. During the debate, no item of information had been more valuable to Broca, none more widely discussed or more vigorously contended, than the brain of Georges Cuvier.

Cuvier, the greatest anatomist of his time, the man who revised our understanding of animals by classifying them according to function—how they work—rather than by rank in an anthropocentric scale of lower to higher. Cuvier, the founder of paleontology, the man who first established the fact of extinction and who stressed the importance of catastrophes in understanding the history of both life and the earth. Cuvier, the great statesman who, like Talleyrand, managed to serve all French governments, from revolution to monarchy, and die in bed. (Actually, Cuvier passed the most tumultuous years of the revolution as a private tutor in Normandy, although he feigned revolutionary sympathies in his letters. He arrived in Paris in 1795 and never left.) F. Bourdier, a recent biographer, describes Cuvier's corporeal ontogeny, but his words also serve as a good metaphor for Cuvier's power and influence: "Cuvier was short and during the Revolution he was very thin; he became stouter during the Empire; and he grew enormously fat after the Restoration."

Cuvier's contemporaries marveled at his "massive head." One admirer affirmed that it "gave to his entire person an undeniable cachet of majesty and to his face an expression of profound meditation." Thus, when Cuvier died, his colleagues, in the interests of science and curiosity, decided to open the great skull. On Tuesday, May 15, 1832, at seven o'clock in the morning, a group of the greatest doctors and biologists of France gathered to dissect the body of Georges Cuvier. They began with the internal organs and, finding "nothing very remarkable," switched their attention to Cuvier's skull. "Thus," wrote the physician in charge, "we were about to contemplate the instrument of this powerful intelligence." And their expectations were rewarded. The brain of Georges Cuvier weighed 1,830 grams, more than 400 g above average and 200 g larger than any nondiseased brain previously weighed. Unconfirmed reports and uncertain inference placed the brains of Oliver Cromwell, Jonathan Swift, and Lord Byron in the same range, but Cuvier had provided the first direct evidence that brilliance and brain size go together.

Broca pushed his advantage and rested a good part of his case on Cuvier's brain. But Gratiolet probed and found a weak spot. In their awe and enthusiasm, Cuvier's doctors had neglected to save either his brain or his skull. Moreover, they reported no measures on the skull at all. The figure of 1,830 g for the brain could not be checked; perhaps it was simply wrong. Gratiolet sought an existing surrogate and had a flash of inspiration: "All brains are not weighed by doctors," he stated, "but all heads are measured by hatters and I have managed to acquire, from this new source, information which, I dare to hope, will not appear to you as devoid of interest." In short, Gratiolet presented something almost bathetic in comparison with the great man's brain: he had found Cuvier's hat! And thus, for two meetings, some of France's greatest minds pondered seriously the meaning of a worn bit of felt.

Cuvier's hat, Gratiolet reported, measured 21.8 cm in length and 18.0 cm in width. He then consulted a certain M. Puriau, "one of the most intelligent and widely known hatters of Paris." Puriau told him that the largest standard size for hats measured 21.5 by 18.5 cm. Although very few men wore a hat so big, Cuvier was not off scale. Moreover, Gratiolet reported with evident pleasure, the hat was extremely flexible and "softened by very long usage." It had probably not been so large when Cuvier bought it. Moreover, Cuvier had an exceptionally thick head of hair, and he wore it bushy.

"This seems to prove quite clearly," Gratiolet proclaimed, "that if Cuvier's head was very large, its size was not absolutely exceptional or unique."

Gratiolet's opponents preferred to believe the doctors and refused to grant much weight to a bit of cloth. More than twenty years later, in 1883, G. Hervé again took up the subject of Cuvier's brain and discovered a missing item: Cuvier's head had been measured after all, but the figures had been omitted from the autopsy report. The skull was big indeed. Shaved of that famous mat of hair, as it was for the autopsy, its greatest circumference was matched by only 6 percent of "scientists and men of letters" (measured in life with their hair at that) and zero percent of domestic servants. As for the infamous hat, Hervé pleaded ignorance, but he did cite the following anecdote: "Cuvier had a habit of leaving his hat on a table in his waiting room. It often happened that a professor or a statesman tried it on. The hat descended below their eyes."

Yet, just as the doctrine of more-is-better stood on the verge of triumph, Hervé snatched potential defeat from the jaws of Broca's victory. Too much of a good thing can be as troubling as a deficiency, and Hervé began to worry. Why did Cuvier's brain exceed those of other "men of genius" by so much? He reviewed both the details of the autopsy and records of Cuvier's frail early health and constructed a circumstantial case for "transient juvenile hydrocephaly," or water on the brain. If Cuvier's skull had been artificially enlarged by the pressure of fluids early during its growth, then a brain of normal size might simply have expanded—by decreasing in density, not by growing larger—into the space available. Or did an enlarged space permit the brain to grow to an unusual size after all? Hervé could not resolve this cardinal question because Cuvier's brain had been measured and then tossed out. All that remained was the magisterial number, 1,830 g. "With the brain of Cuvier," wrote Hervé, "science has lost one of the most precious documents it ever possessed."

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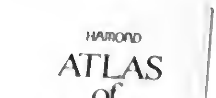

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On the surface, this tale seems ludicrous—comic relief after three turgid columns inspired by a panda's thumb. The thought of France's finest anthropologists arguing passionately about the meaning of a dead colleague's hat could easily provoke the most misleading and dangerous inference of all about history—a view of the past as a domain of naïve half-wits, the path of history as a tale of progress, and the present as sophisticated and enlightened.

But if we laugh with derision, we will never understand. Human intellectual capacity has not altered for thousands of years so far as we can tell. If intelligent people invested intense energy in issues that now seem foolish to us, then the failure lies in our understanding of their world, not in their distorted perceptions. Even the standard example of ancient nonsense—the debate about angels on pinheads—makes sense once you realize that theologians were not discussing whether five or eighteen would fit, but whether a pin could house a finite or an infinite number. In certain theological systems, the corporeality or noncorporeality of angels is an important matter indeed.

In this case, a clue to the vital importance of Cuvier's brain for nineteenth-century anthropology lies in the last line of Broca's statement, quoted above: "In such data, we hope to find some information relevant to the intellectual value of the various human races." Broca and his school wanted to show that brain size, through its link to intelligence, could resolve what they regarded as the primary question for a "science of man"—explaining why some individuals and groups are more successful than others. To do this, they divided people according to a priori convictions about their worth—men versus women, whites versus blacks, "men of genius" versus ordinary folks—and tried to demonstrate differences in brain size. The brains of eminent men (literally males) formed an essential link in their argument—and Cuvier was the *crème de la crème*. Broca concluded:

In general, the brain is larger in men than in women, in eminent men than in men of mediocre talent, in superior races than in inferior races. Other things equal, there is a remarkable relationship between the development of intelligence and the volume of the brain.

Broca died in 1880, but disciples continued his catalog of eminent brains (indeed, they added Broca's own to the list—although it weighed in at an undistinguished 1,484 g). The dissection of famous colleagues became something of a cottage industry among anatomists and anthropologists. E.A. Spitzka, the most prominent American practitioner of the trade, cajoled his eminent friends: "To me the thought of an autopsy is certainly less repugnant than I imagine the process of cadaveric decomposition in the grave to be." The two premier American ethnologists John Wesley Powell and W J McGee made a wager over who had the larger brain—and Spitzka contracted to resolve the issue for them posthumously. (I am reminded of the scene in Gilbert and Sullivan's *Mikado,* when Ko-Ko attempts to persuade Nanki-Poo to "be beheaded handsomely at the hands of the Public Executioner: . . . When it's all over, general rejoicings, and a display of fireworks in the evening. You won't see them, but they'll be there just the same." It was a toss-up in any case. The brains of Powell and McGee differed very little, no more than varying body size might require.)

By 1907, Spitzka could present a tabulation of 115 eminent men. As the list grew in length, ambiguity of results increased apace. At the upper end, Cuvier was finally overtaken when Turgenev broke the 2,000-g barrier in 1883. But embarrassment and insult stalked the other end. Walt Whitman managed to hear the varied carols of America singing with only 1,282 g. Franz Josef Gall, a founder of phrenology—the original "science" of judging mental worth by the size of localized brain areas—could muster only 1,198 g. Later, in 1924, Anatole France almost halved Turgenev's 2,012 and weighed in at a mere 1,017 g.

Spitzka, nonetheless, was undaunted. In an outrageous example of data selected to conform with a priori prejudice, he arranged, in order, one of his largest brains from an eminent white male, a bushwoman from Africa, and a gorilla. (He could easily have reversed the first two by choosing a larger black and a smaller white.) Spitzka concluded, again invoking the shade of Georges Cuvier: "The jump from a Cuvier or a Thackeray to a Zulu or a Bushman is no greater than from the latter to the gorilla or the orang."

Such overt racism is no longer common among scientists, and I trust that no one would now try to rank races or sexes by the average size of their brains. Yet our fascination with the physical basis of intelligence persists (as it should), and the naïve hope remains in some quarters that size or some other easily measured external feature might capture the subtlety within. Indeed, the crassest form of more-is-better—using a rapidly measured quantity to assess improperly a far more subtle and elusive quality—is still with us. And the method that some men use to judge the worth of their penises or their automobiles is still being applied to brains. This column was inspired by a recent report on the whereabouts of Einstein's brain (*Science,* August 25, 1978). Yes, Einstein's brain was removed for study, but 23 years after his death, the results have not been published. The remaining pieces—others were farmed out to various specialists—now rest in a Mason jar packed in a cardboard box marked "Costa Cider" and housed in an office in Wichita, Kansas. Nothing has been published because nothing unusual has been found. "So far it's fallen within normal limits for a man his age," remarked the owner of the Mason jar.

Did I just hear Cuvier and Anatole France laughing in concert from on high? Are they repeating a famous motto of their native land: *plus ça change, plus c'est la même chose* ("the more things change, the more they remain the same"). The physical structure of the brain must record intelligence in some way, but gross size and external shape are not likely to capture anything of value. I am, somehow, less interested in the weight and convolutions of Einstein's brain than in the near certainty that people of equal talent have lived and died in cotton fields and sweatshops.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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This year, the Grand Prize of *Natural History*'s Photographic Competition will be a ticket for the American Museum of Natural History's Discovery Tour through the Aegean and the Middle East. The winner will fly from New York to Athens, from where the tour's cruise ship will sail for Egypt, Israel, Cyprus, and Turkey. The tour will include a three-day excursion to Cairo and Luxor, a two-day trip to Bethlehem and Nazareth, and visits to Jerusalem, Rhodes, and Istanbul. The Grand Prize-winner will have the chance to photograph such magnificent sites as the Temple of Poseidon at Sounion, the church of Saint Sophia, and the Seraglio in the Topkapi Palace Museum, as well as the Aegean's spectacular scenery.

Besides the Grand Prize, the 1979 competition offers cash prizes totaling more than $3,000. The winning entries will be published in a special double issue of *Natural History* in August and exhibited at the American Museum of Natural History.

The four categories—broad enough to fit the interests of any photographer—are: (1) The Natural World; (2) A Sequence of an Event in Nature; (3) Photomicrography, including pictures with a scanning electron microscope; and (4) The Human Environment. First prize in each category is $500. In addition, all entries are eligible for the following awards: Humor in Nature, $200; Urban Wildlife, $200; and ten Honorable Mentions at $100 each.

The deadline is April 15, 1979. Please put your name and address on every entry and include a stamped, self-addressed envelope—since we do want to return your pictures to you.

To all, the very best luck!

THE RULES

1. The competition is open to everyone except employees of the American Museum of Natural History and their kin.
2. Competitors may submit up to three previously unpublished entries in each of the four categories. Decision of the judges is final.
3. The Museum acquires the right to publish, exhibit, and use for promotion the winning photographs. The Museum assumes no responsibility for other entries.
4. Entries may be transparencies or prints up to 8 by 10 inches, and each must bear the photographer's name and address.
5. Enclose a self-addressed, stamped envelope for the return of entries.
6. Entries must be postmarked no later than April 15, 1979.

Pack them carefully and mail to:

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The Semisocial Manatee

A large marine mammal plays follow-the-leader without a leader

The mammals most completely adapted to an aquatic environment belong to two orders: the Cetacea (whales, dolphins, and porpoises) and the Sirenia (manatees and dugongs). These are the only mammals that spend their entire lives in the water. Morphologically, the members of these orders are similar; for example, all have large, streamlined bodies, lack hindlimbs, have modified forelimbs, and use tail flukes for locomotion. The sirenians, however, are the only herbivorous marine mammals.

There are four sirenian species in existence today: the dugong, a single species found in the Indo-Pacific, and three species of manatees—the West African, Amazonian, and West Indian, or Caribbean. Another sirenian, Steller's sea cow, was exterminated in the eighteenth century. The four extant species are considered endangered at both the national and international levels, but in the United States, the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973 provide the animals some protection.

The endangered status of the sirenians is probably due to two

by John E. Reynolds III

main factors: historical overexploitation by humans, primarily for food and oil, and the animals' apparent low reproductive rates. While intentional harvesting of sirenians has been greatly reduced in most countries in which they are found, other human activities still account for a large percentage of their total mortality. For example, in Australia, large numbers of dugongs are drowned by the shark nets that protect the beaches there, and in Florida, manatees frequently die when struck by motorboat propellers or trapped by the automatic flood-control dams found on many waterways.

Because they require shallow-water plants, the sirenians are restricted to coastal marine, estuarine, and freshwater habitats. And while they live in proximity to man, the sirenians are nonetheless poorly known biologically. Only in the areas of gross anatomy and osteology is there relatively abundant literature concerning sirenians, and until recently, detailed field studies of the behavior and ecology of the animals were nonexistent.

The West Indian species (*Trichechus manatus*) is the most thor-

Jeff Foott

Munching on a water hyacinth, far left, this manatee is inadvertently helping to control a menace to river navigation. These prolific plants are a favored food of this large marine herbivore. Left, a calf will nurse for up to eighteen months. The manatee pictured below is floating along in the Crystal River, Florida, napping. It must come to the surface every four to fifteen minutes to breathe.
Overleaf: Manatees tend to swim in herds. The herds are unstable, but a common feature is similar-sized individuals. When a female comes into estrus, several bulls will congregate around her, each attempting to mate.

Jeff Foott

oughly studied manatee. About 14,000 West Indian manatees are scattered over a broad geographic area—from the southeastern United States to northeastern Brazil and throughout the Caribbean region. Since the animals are apparently incapable of surviving extremely cold temperatures, the manatee population within the United States is normally restricted to Florida. But during warm summer months, manatees have been sighted as far north as North Carolina and Virginia. Current estimates put the United States population at between 750 and 1,000, and most are concentrated in six Florida locations: Crystal River/Homosassa Springs, Charlotte Harbor/Ten Thousand Islands, Everglades National Park, southeastern Florida (Miami to Fort Pierce), Brevard County, especially near Titusville, and Blue Springs.

Two comprehensive field projects have provided insights into manatee behavior, feeding habits, diurnal rhythms, and environmental requirements. One study, at Crystal River in northwestern Florida, was done in the late 1960s and early 1970s primarily by Daniel S. Hartman, whose assistant, James Powell, has continued observations of the manatees to the present. The other project, on herd structure, which I conducted from 1974 to 1977, was done at Blue Lagoon Lake, a freshwater area in Miami, Florida.

Manatees at Blue Lagoon generally swim in herds rather than singly. Two or three manatees of either sex usually make up a herd, but the size of the individuals is not random. This suggests that, to some extent, manatees segregate according to size.

Herds are normally unstable and the component members shift frequently. In fact, of sixty manatees in Blue Lagoon, virtually no pair was observed more than once or twice during our 22-month study. There are two main exceptions to the general looseness of manatee social structures: juvenile males may remain together for prolonged periods and the mother–calf bond is a long one, probably exceeding a year. (Bachelor-herd formation and prolonged maternal bonding are not unusual among social mammals; they also characterize fur seal and sperm whale populations.)

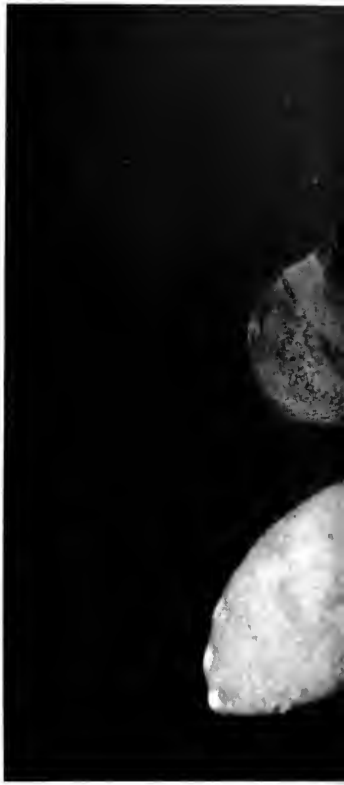
A female in estrus becomes the focal point of an "estrous herd," a group of as many as 17 male manatees and the female, which sometimes remains together for up to a month. The estrous female often twists and turns violently, apparently to escape her entourage. The bulls do not appear to compete for the cow in the sense that they estab-

Jeff Foott

Janet Ann Fries

Although it is covered by the U.S. Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973, the status of the West Indian manatee remains precarious. An estimated 750 to 1,000 manatees, a fraction of their former numbers, survive in Florida waters. Habitat destruction, harassment, and boating accidents are major reasons for the decline. Most adults show deep scars on their bodies, the results of being sliced by the propellers of pleasure boats. Florida has created refuges in which boats must proceed at idle speed, but the rules are often ignored.

Jeff Foott



lish defended territories around her. Rather, each bull simply attempts to remain adjacent to the female, presumably to be the first animal to mate with her. Not surprisingly, bulls sometimes collide with one another during their efforts.

At Blue Lagoon, female manatees being pursued by bulls frequently swam into shoals, possibly to prevent the males from reaching their undersides to mate. Occasionally, cows in shallow water raised their tails out of the water, slapping approaching males on the downstroke. Whether this was done intentionally was not clear, but in two instances where such behavior was observed, the bulls backed away from the female and swam into deeper water.

Mating can happen either at the surface or underwater. Often, more than one male mates with an estrous female, and no single posture is assumed during copulation. Some pairs remain horizontal in the water column, others vertical. Frequently, the bull turns upside down and swims below the female, but mating can also take place with the animals on their sides, facing one another.

After a consort period, during which the bulls remain with the female, the estrous herd breaks up, and the males and impregnated female separate. The gestation time is thought to be about 400 days, but this figure is unproved. Another estimate, which also lacks supporting data, is that adult females give birth every 2.5 to 3 years.

Manatee calves are born year-round, although calving peaks in late spring to early summer. Most pregnancies produce one calf, but twins are thought to occur. The precocious calves are able to swim with their mothers within minutes of birth. A young animal commonly remains close to its mother's side, and this behavior is especially evident when the animals swim together. Adult manatees typically swim in single file, but a calf always travels parallel to its mother, directly behind her flipper. This swimming formation could be adaptive for two reasons: the animals can communicate most effectively in this position or the formation is hydrodynamically advantageous if the calf experiences less drag from the water.

The females do not attack other manatees or humans that approach their young. Instead, they attempt to keep other manatees and human divers away from their calves by swimming between the intruder and their offspring. If the danger is perceived as severe, the female and the calf will flee. A fleeing female–calf pair produce a duet, with one animal vocalizing and the other emitting an

answering call. In one instance near Blue Lagoon, a female manatee was separated from her young by a partly opened floodgate. The opening was too small for the mother to pass, and the current was too strong for the calf to swim back upstream through the opening. For at least three hours, the mother manatee attempted to maintain contact with her calf by repeatedly placing her head through the narrow opening of the gate and vocalizing. Eventually, the gate opened enough so that she could swim through and rejoin her calf.

Another aspect of herd behavior involves social facilitation, a behavior pattern that is increased in pace or frequency by the behavior of other animals. Social facilitation is apparent in many manatee activities, including feeding, resting, nuzzling, body surfing, and follow-the-leader.

Body surfing involves groups of manatees riding the powerful currents generated below flood dams when the gates are partly open. Sessions of body surfing can last more than an hour, with manatees repeatedly riding the currents in parallel formation. There are, interestingly enough, many variations on the basic theme of riding the currents by simply facing downstream. Sometimes the animals ride the currents parallel to each other, but broadside to the current; they also cut diagonally back and forth across the currents. Throughout the ride, the parallel formation is not broken, and the animals perform in a coordinated fashion. Body surfing manatees frequently nuzzle one another and vocalize between rides.

Follow-the-leader is less spectacular than body surfing, but it also involves coordinated behavior in which two or more manatees follow one another in single file and synchronize all their activities, such as breathing, diving, and changing direction. Despite the term follow-the-leader, there is no dominant herd leader in the usual sense of the word. Leadership, in fact, was not discernible in any type of manatee herd at Blue Lagoon.

Activities such as follow-the-leader and body surfing are similar to behavior that in other species is called play. Are they really playing? Strict definitions of the term play are based on "normal" behavior of the species being considered. Since there is not enough information to indicate what is normal for manatees, body surfing and follow-the-leader cannot as yet be called play.

Obviously, for body surfing and follow-the-leader, communication is important in synchronizing the behavior of individuals in a group. Communication in manatees is

Jeff Foott

An aerial view shows a group of manatees feeding in shallow water. They alternate between saltwater bays, brackish estuarine areas, and rivers. These marine mammals seem to need fresh water to drink.

tively unstudied at present, but some researchers believe that acoustics are very important. At Blue Lagoon, however, the animals vocalized infrequently. Manatee vocalizations, which are usually squeals and squeaks, may simply indicate excitement, fright, or the presence of an animal in the area. Anatomical studies of manatees indicate their vision is poor. One way in which manatees may coordinate and synchronize activities involves mechanoreception. Acoustic communication is, strictly speaking, mechanoreception, since it depends on nervous impulses produced by the physical movement of hairs. Other types of mechanoreception could work as follows: Manatees' bodies have numerous sparse hairs; if a movement underwater caused a movement of these hairs that was detected by nerve cells, the animals might use a pressure reception system analogous to the lateral line of fishes. The presence of such a system has yet to be demonstrated, but it is an interesting hypothesis.

Observations of the herd structure, communication, and coordinated behavior of West Indian manatees have allowed us to tentatively define manatee social behavior. Although they tend to be found in herds and are capable of coordinated behavior, manatees are only moderately social. This is in contrast to such marine mammals as dolphins and sea lions, as well as many others.

Many researchers think that manatees drift in and out of groups and perform activities without regard to the time of day or night. The idea is certainly not unreasonable; an animal lacking natural predators and having abundant food might easily spend its time feeding, resting, and socializing in a random fashion. I was, therefore, surprised to find that manatees in Blue Lagoon showed activity patterns.

Some areas of Blue Lagoon were used at certain times of day for given activities, involving, in many cases, fairly constant herd sizes. Nuzzling, possibly a chemosensory means by which manatees identify each other, and feeding were two very common activities, occurring throughout the day in various parts of the lake. Resting mainly took place in a few secluded areas of the lake, but it was observed throughout the day. Cruising (prolonged swimming), body surfing, and follow-the-leader required some exertion by the manatees, and these activities occurred primarily in the early morning or late afternoon, when temperatures were lower, as well as when boating activity diminished.

Manatees seem to perform the same activities at night as they do during the day; that is, they spend most of their time intermittently feeding and resting. The ratio of time spent in these two activities is exemplified by a female that spent about 42 percent of her time resting, and 49 percent feeding. Her calf rested and fed 78 percent and 17 percent of the time, respectively, during one day. This implies that less than 10 percent of a manatee's total daily routine involves activities other than resting or feeding. (By contrast, humans who spend eight hours a day sleeping and two hours preparing and eating food devote about 60 percent of their time to other activities.)

The large amount of time that an adult manatee spends feeding has caused speculation regarding the quantity of food it requires to survive. Any estimate of daily consumption must consider the size of the manatee. Captive adults seem to do well if they are fed 65 to 110 pounds wet weight of vegetation daily; however, these animals are fed a variety of unnatural foods, and they are unable to move about as freely as wild manatees do. Considering that manatees can exceed 12 feet in length and weigh more than 2,200 pounds, it seems safe to say that an adult manatee in the wild could consume at least 110 pounds of vegetation daily.

Despite the great amount of time they spend feeding, manatees are not simply gigantic eating machines. They are moderately social animals, have prolonged maternal bonding, are usually found with others of their kind, and are capable of coordinated behavior. They can also communicate with each other rather effectively.

This type of information is necessary to construct conservation and management programs designed to save manatees from extinction. But more will have to be learned about the social structure, population dynamics, and resource exploitation of these marine mammals before efforts can be mounted that will insure not only their survival but also an increase in their currently diminished numbers. □

Exclusively herbivorous, manatees feed on a variety of saltwater, brackish, and freshwater plants. An adult may consume up to one hundred and ten pounds of vegetation in a single day.

Jeff Foo

Long-lived Seeds

by Robert Edward Cook

They may lie dormant for centuries, until light or earth movement triggers germination

Henry David Thoreau appreciated the magic of seeds. In 1857, he planted six large yellow squash seeds sent to him by the Patent Office, and the ground yielded five very large fruits. He thought them worth describing in an essay entitled "The Succession of Forest Trees," which appeared in the *New York Tribune*, October 6, 1860:

> Who would have believed that there were 310 pounds of *poitrine jaune grosse* in that corner of my garden? These seeds were the bait I used to catch it, my ferrets which I sent into its burrow, my brace of terriers which unearthed it. . . . Other seeds I have which will find other things in that corner of my garden, in like fashion, almost any fruit you wish every year for ages, until the crop more than fills the whole garden. . . . Perfect alchemists I keep who can transmute substances without end, and thus the corner of my garden is an inexhaustible treasure-chest.

In this essay, Thoreau is concerned with the development of forests. He wished to explain why an oak woodland sprang up after a pine woodland was cut down. The answer, he suggested, lay quite literally in seeds: this succession of plants comes from seeds lying dormant in the soil of the pinewood before cutting or from seed carried in by birds and hoarding squirrels. Thus, the dramatic changes in vegetation that often follow abandonment of farmland could be explained by the dispersal of seeds. The study of the succession of forest trees was generally ignored for thirty years after Thoreau's death, but about the turn of the century it became the cornerstone of American plant ecology because of the writings of pioneer plant ecologist Frederic Clements.

Today the study of seeds is almost synonymous with the biology of dispersal in plants. The problem is the same: seedlings must find a suitable patch of habitat in which to grow and reproduce. Shady spots beneath the mother plant are usually adverse to the survival and growth of seedlings, and botanists have generally interpreted the diversity and elaborate forms of seeds and fruits as adaptations for delivering seeds to more hospitable locations for germination and growth.

One has only to watch the flight of maple samaras in the fall or pick burs from a woolen shirt to appreciate the aesthetics of seed forms and their apparent effectiveness in dispersal. However, seeds spend only a short, early portion of their lives as travelers; most of the time seeds live in the soil, waiting for conditions favorable for germination. For some, such a life may be very long indeed and the key to the meaning of seeds.

To paraphrase Samuel Butler, a plant is just a seed's way of making another seed. A seed may display as impressive a set of adaptations for survival as any adult plant, whether orchid or redwood; the most striking adaptation may be the capacity to remain alive for long periods of time while lying dormant in the soil. Encased in a hard, protective coat and provisioned with internal sustenance from the mother plant, the seed enjoys a unique freedom from requirements for light, water, or mineral nutrients. However, no seed is immortal, and at some point it must germinate, become a plant, and produce at least one more of its kind to replace itself in the population. Much of the special magic of seeds lies in their ability to sense the appropriate occasion for germination, the conditions that will greatly enhance the chance of producing a new seed.

Further on in his essay on forest succession, Thoreau described a dormant seed's life:

> Yet I am prepared to believe that some seeds, especially small ones, may retain their vitality for centuries under favorable circumstances. In the spring of 1859, the old Hunt house, so called, in this town, whose chimney bore the date 1703, was taken down. This stood on land which belonged to John Winthrop, the first governor of Massachusetts, and a part of the house was evidently much older than the above date, and belonged to the Winthrop family. For many years I have ransacked this neighborhood for plants, and I consider

A maple seed, encased in a hard covering attached to a wing adapted for wind-borne dispersal, has germinated. Normally, maple seeds germinate rapidly, rarely lasting over one winter.

Bill Swan, Peter Arnold

W. H. Hodge Peter Arnold

Encased in fleshy fruit, the seeds of the Japanese yew, above, will be dispersed when they are eaten by birds. Right, goatsbeard seeds are attached to parachutes of feathery hairs, which are caught by the wind and carried far from the mother plant. The small, hard-covered seeds of goatsbeard may lie dormant in the soil for many years until appropriate environmental conditions stimulate germination.

myself familiar with its productions. Thinking of the seeds which are said to be sometimes dug up at an unusual depth in the earth, and thus to reproduce long extinct plants, it occurred to me last fall that some new or rare plants might have sprung up in the cellar of this house, which had been covered from the light so long. Searching there on the 22d of September, I found, among other rank weeds, a species of nettle (*Urtica urens*) which I had not found before; dill, which I had not seen growing spontaneously; the Jerusalem oak (*Chenopodium Botrys*), which I had seen wild in but one place; black nightshade (*Solanum nigrum*), which is quite rare hereabouts, and common tobacco, which, though it was often cultivated here in the last century, has for fifty years been an unknown plant in this town, and a few months before this not even I had heard that one man, in the north part of town, was cultivating a few plants for his own use. I have no doubt that some or all of these plants sprang from seeds which had long been buried under or about that house, and that that tobacco is an additional evidence that the plant was formerly cultivated here. The cellar has been filled up this year, and four of those plants, including the tobacco, are now again extinct in that locality.

Thoreau clearly observed the significance of weedy species producing small seeds, as well as the remarkable longevity of some seeds in the soil. A number of nineteenth-century botanists had attempted, with some success, to germinate seeds from herbarium specimens collected many years earlier, but the first systematic attempt to demonstrate the longevity of seeds in the soil was the experiment begun in 1879 by W. J. Beal, a botanist at Michigan Agricultural College. He buried seeds of a number of common species in twenty replicate, sand-containing bottles and dug one bottle up at five- or ten-year intervals to germinate the survivors. The results of this and similar burial experiments indicated that the seeds of a large number of species, particularly weedy and ruderal species, can easily survive for fifty years without germination. The seeds of trees, shrubs, and many grasses apparently lose viability very quickly.

The most remarkable records of seed longevity come from the investigations of a Danish botanist, Soren Odum, who, along with archeologists from the National Museum of Denmark, excavated sites of known age. The soils from such digs frequently yield a diverse flora rich in ruderals such as might be found growing on dumping grounds or along roadsides. The most remarkable discoveries came from a hill north of Vestervig church in Thy, in northwestern Jutland. Ødum took soil samples out of the remains of an Iron Age settlement (ca. 100 B.C.–A.D. 400), and he managed to germinate one seed of lamb's-quarters (*Chenopodium album*) and three of corn spurry (*Spergula arvensis*), both weedy annuals more than 1,700 years old. He also found that 600-year-old seeds commonly germinate from soils of other excavations and the resultant plants appeared to grow and produce seed normally. Many of these species were also annual weeds thought to live for a single growing season and die. Some "annual" plants really seem to be very long-lived perennials that merely spend the last year of their lives as flourishing leafy herbs.

Current interest in the longevity of seeds comes primarily from seedsmen and plant breeders who wish to store seeds on the shelf for future sowing. They have concentrated on the aging process in seeds and have found that much loss of viability is due to the accumulation of genetic and membrane damage in cells of the plant embryo. Curiously, these workers discovered that seeds in the soil often have much greater longevities than seeds stored dry on shelves. Many seeds in the soil seem to live fully hydrated, so germination must be inhibited by some factor other than lack of moisture. This hydrated condition allows seeds to maintain a low level of activity, including cellular repair mechanisms that prevent the accumulation of damage, whereas the very dry state of shelf-stored seeds leads to loss of viability. The differing abilities of species to remain alive in the soil for long periods could largely reflect the varied efficiencies of these cellular repair processes.

The mechanisms that prevent

buried seeds from germinating are not completely understood, but the role of light appears critical. The importance of light was discovered in the 1960s by two plant biologists who dug up soil samples from a fallow pasture during the middle of the night. Knowing the history of the site, these workers expected to find an abundant flora of weed seed in the ground, and they proceeded to germinate half their sample in the light and half in the dark. After six weeks they found that a great number of seedlings had come up in the illuminated trays, while the seeds in the dark remained dormant. Subsequently, this light requirement for germination was shown to be absent before burial, since mature seed taken directly from the mother plant readily germinated in the dark when moistened. The biologists concluded that burial itself induced a germination requirement for light in the seed. Buried individuals with such a requirement would remain dormant until some form of disturbance brought them to the surface.

These light-sensitive seeds not only monitor the presence or absence of light but also respond to its quality. In the seed, light transforms phytochrome, a very sensitive pigment, into a form that promotes germination. This chemical transformation and its effect on germination can be reversed by light that lacks the red portion of its spectrum. The seed's finely tuned response to the color of light made little sense until workers realized that most of the red portion of the spectrum of light that passes through the green leaves of a plant is absorbed in the process of photosynthesis. Thus, seeds beneath a canopy of leaves will probably remain dormant, and only when sufficient disturbance removes existing vegetation will germination and growth begin. These conditions, which usually favor a plant's successful production of new seeds, are precisely those that the farmer creates each spring when he plows his winter grass and last year's stubble into the soil.

Farmers have long cursed the number of seeds in the soil because they are the source of the rank growth of weeds that reduce crop yield in their fields each season. Charles Darwin appreciated the farmers' complaint in his *Origin of Species*.

> I do not believe that botanists are aware how charged the mud of ponds is with seeds; I have tried several little experiments, but will here give only the most striking case: I took in February three tablespoonfuls of mud from three different points, beneath water, on the edge of a little pond; this mud when dried weighed only six and three-fourth ounces; I kept it covered up in my study for six months, pulling up and counting each plant as it grew; the plants were of many kinds, and were altogether 537 in number; and yet the viscid mud was all contained in a breakfast cup!

To the farmer, weeds can be as much of a pest as any outbreak of insects. Because of the economic loss caused by great numbers of weeds, agronomists have studied the seed flora in different soils since the turn of the century. Arable ground may contain as many as 100,000 dormant seeds per square meter, of which only a small fraction usually germinated in a given year. Before the development of herbicides, farmers could do little about weeds except fallow their fields for several years and plow under the resultant weeds before they produced more seeds. Frequently the weeds won this contest and the land was abandoned for more profitable ground. When land is abandoned, the process of vegetational succession begins. Within a year or two, such fields are overrun by weedy annuals and short-lived perennials, and a vast number of seeds are deposited back into the soil. Gradually, competitively aggressive grasses, which have extensive root systems and prolific vegetative spread, eliminate the herbs. Slowly the seeds of shrubs and trees colonize the field, germinating and growing in pockets of soil. Once saplings form a canopy over the grasses, the ground vegetation is rapidly shaded out, and the former farmland is well on its way to becoming a dense forest.

Meanwhile an equally stringent process of elimination is taking place below the surface of the soil as the hidden flora begins to decay.

W. H. Hodge, Peter Arnold

Left, the red oak's seeds are its acorns, which do not last more than a year: they are eaten by squirrels or they rot. Below, as pine cones mature and dry out, their scales open and release the tree's seeds. Although the heavy seeds may escape from the cone over several months, they germinate rapidly once they fall into soil.

John R MacGregor, Peter Arnold

Above, the fruit capsule of jimson weed opens to release the small, hard seeds inside. Most will fall near the mother plant and lie dormant for long periods. Corn kernels, right, normally germinate very rapidly. Primitive corn, which had no cob, resembled grass; its seeds probably germinated slowly.

The seeds of species that do not require light for germination may sprout to meet a certain death deep in the soil or in the shade of the surface vegetation. Those species with short longevity, due perhaps to inefficient cellular repair mechanisms, reach the end of their dormant lives and disintegrate. As years pass, the sole survivors are seeds with well-adapted dormancy mechanisms; by and large these are the weedy annuals that were part of the surface vegetation for only a year or two. Yet until some form of disturbance transforms them into growing plants, they appear to be perfectly adapted to their long, quiet lives as seeds in the soil, living to ripe old ages that can last centuries. Not surprisingly, ecologists have found in the soils beneath very old forests and pastures a diverse flora of early successional species, waiting for an opportunity to renew their numbers.

Weeds and early successional ruderals appear very well adapted to the highly disturbed soil conditions characteristic of cultivation. And in many ways, the abundance of weeds and the nature of vegetational change have been shaped by human impact on the landscape. Yet species of weeds have existed for millions of years, long before vast areas of this continent were brought under cultivation. What was the primeval habitat of these species when much of the surface vegetation consisted of virgin forest and prairies? Were these ruderals extremely rare, surviving in marginal habitats such as stream banks, rock outcrops, and eroding talus slopes? Or was the frequency of such disturbances as fire, floods, and violent storms much greater in the past than popular notions of the stable primeval forest imply?

The adaptations of seeds give some clue to the conditions under which they evolved. Weed seeds in particular seem to be remarkably suited to living long lives in the soil. While seed dispersal generally involves the movement of offspring away from the mother plant to a geographically different location, some seeds might disperse in time, lying dormant in the soil until disturbance creates a favorable patch of habitat. Only then would their lives as plants begin, leading to rapid growth and the production of a large number of new seeds. For such a life history to have been adaptive, not only would seeds have had to evolve the capacity for great longevity in the soil, but disturbance in the primeval forest must have been frequent enough to have maintained an abundant seed population underground.

There is a growing body of evidence that some prehistoric forests were continually ravaged by fires, ice storms, and severe erosion. One such study reconstructed the history of a virgin forest in New England and found that the standing vegetation was completely destroyed by severe hurricanes about every 150 years. Even local disturbance caused by animals or the toppling of single trees may have been enough to maintain an abundant seed flora in the soil. For example, in June of 1749, the Swedish botanist Peter Kalm, while traveling through the virgin forests of northern New York to Montreal, noted in his journal:

> Almost every night we heard some trees crack and fall while we lay here in the wood, though the air was so calm that not a leaf stirred. . . . When the wind blows hard it is reckoned very dangerous to sleep or walk in the woods on account of the many trees which fall in them; and even when it is very calm there is some danger in passing under very large and old trees. I was told, in several parts of America that the storms or hurricanes sometimes pass over only a small part of the woods and tear down the trees in it; and I have had opportunities of confirming the truth of this observation by finding places in the forests where almost all the trees had crashed down, and lay in one direction.

Whether these really were the conditions that led to the evolution of weedy species will be very difficult to establish; human activity has obliterated nearly all evidence and set the evolution of weeds on a new course. But certainly, many weeds have evolved a tremendous capacity for longevity in the soil, a capacity that presumably reflects the habitat in which most of the ancestors of these plants found themselves. □

Jeanne Heiberg; Peter Arnold

THIS IS AN AD FOR PEOPLE WHO THINK ALL THE LITTLE COUNTRY INNS ARE IN OTHER PEOPLE'S COUNTRIES.

They seem to have been lifted, setting and all, out of some other place. The French countryside, an English village, the Swiss Alps.

North Carolina's country inns. You see them standing tall on the mountaintops, tucked into green and yellow valleys, set back in the trees beside a winding road.

And, while the feeling may be European, the hospitality is strictly Southern. One innkeeper says it's "like having company all the time."

You'll find fresh flowers and four-poster beds. Music boxes and dinner bells. Long tables loaded with steaming platters of home-grown, home-cooked food.

And outside your window, and off the wide verandahs, scenery like you thought you could only find on picture postcards.

The famous and the obscure have warmed themselves at the great stone fireplaces of the inns. Aaron Burr. John C. Calhoun. Woodrow Wilson. F. Scott Fitzgerald. William Jennings Bryan.

George Washington never slept at any of them, of course. But Cornwallis (a gentleman who reportedly caused him to lose quite a bit of sleep) did.

The inns, in a way, are North Carolina in miniature. Because the warmth

of the people, the reverence for nature, the deep sense of history are e[illegible]
you go. Everywhere the inns are. From the mountains to the sea.

So come, this year. Bring your camera, your heartiest appetite, a[illegible]
comfortable shoes. And spend your vacation in a fascinating [illegible]

NORTH CAROLINA

Of Libyan Jirds and Fat Sand Rats

by Martin Daly

With salty bushes for food, gerbils living in the Sahara need the most powerful kidneys known to science

Every morning in the Algerian oasis town of Beni-Abbès, the Saharan night is abruptly ended just before dawn by the first prayer call. The tinnily amplified wail of the muezzin rouses the jackals in the little zoo in the center of town, and they answer him, drown him out in fact, with a great, harmonious howl.

For the faithful, it is time to shuffle down to the mosque. And for me during two serene six-month stays in Beni-Abbès, it was time to start work: to see what nocturnal gerbils had entered my traps, to record their identities and other data before releasing them, and to observe the morning activities of the diurnal gerbils.

Gerbils are the dominant rodents of the Great Palaearctic Desert, a continuous stretch of arid lands that extends all the way from the Atlantic shores of Mauritania, through the Sahara and the Middle East, to southern Siberia. They constitute a subfamily, Gerbillinae, of the large rodent family Cricetidae, which also includes hamsters, voles, muskrats, lemmings, pack rats, and white-footed mice. There are between fifty and one hundred species of gerbils (depending on which taxonomist you read), ranging from tiny, mouselike forms to large rodents reminiscent of ground squirrels. Most look much like the Mongolian gerbils that have become familiar pets in Europe and North America since the 1950s.

Although virtually confined to true desert and adjacent semiarid regions, gerbils are not without economic importance. They have become agricultural pests in irrigated areas of India, the USSR, and other countries. This is a minor nuisance compared to the terrible role these rodents have played in human affairs in the past, for the far-flung gerbil populations of central Asia and North Africa are natural reservoirs of endemic bubonic plague. Rats were the medium that carried the devastating Black Death throughout Asia and Europe during the Middle Ages, but the bacterium responsible has survived the centuries in gerbils.

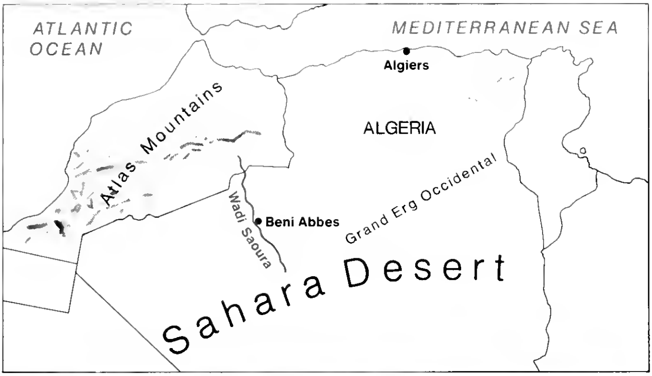
For these reasons, gerbils have been the objects of considerable ecological research, particularly in the USSR. At the same time, they have become popular subjects for behavioral and other research in Western nations, particularly in the United States. This latter trend must be ascribed to more prosaic considerations than plague and pestilence—Mongolian gerbils are easy to breed, rarely bite, and don't smell as bad as rats or mice.

When I first arrived in Beni-Abbès in 1972, the behavior of gerbils in nature was little known. The literature contained scattered observations by Soviet, Indian, Arab, Israeli, and French ecologists, but no one primarily interested in behavior had conducted a field study. I was certain that subjects for my research would be available, for the region of Beni-Abbès was by no means terra incognita. The site was commended

Roland Vernet

Chewing on souït, a fat sand rat, left, ingests both food and water from this succulent Saharan saltbush. Near Beni-Abbès, the sand habitat of the erg, right, supports two species of gerbils.

Kazuyoshi Nomachi



Martin Daly

Sprawling over a bank of the Wadi Saoura, Beni-Abbès has an ample supply of fresh water drawn from under the erg. The whitewashed fortress is a former headquarters of the French Foreign Legion.

to me by the French mammalogist Francis Petter, who had conducted important taxonomic and ecological studies of the local rodents. I knew that he had found eight different species of gerbils, representing four genera, in the environs of this single oasis. This diversity of species depends upon the diversity of habitats around the oasis.

Three distinct types of desert habitat make up the surroundings at Beni-Abbès: the erg, the hamada, and the wadi. Of these the most sparsely vegetated is the erg, a vast sea of rolling sand dunes, but it supports a surprising array of animals—gerbils and jerboas, lizards and vipers, beetles and flies. Most bizarre of the erg inhabitants are the "sandfish," lizards that swim beneath the sand's surface, with their little limbs so snugly fitted into perfectly shaped depressions in their sides that they are as streamlined as a pike.

A richer habitat is the hamada, gravelly plains with small patches of bushy perennial vegetation wherever soil has accumulated in a depression. The Hamada du Guir begins on the bank of the Wadi Saoura opposite from Beni-Abbès and extends unbroken for miles. Of the three habitats, the hamada contains the greatest diversity of animal forms: more kinds of gerbils, reptiles, and insects, and many more birds—a variety of larks and wheatears, coursers, trumpeter bullfinches, ravens, and bustards.

The wadi separates the erg from the hamada. A vast canyon, which narrows to less than a mile at Beni-Abbès, the Wadi Saoura is a part-time river. Draining a huge area of the south slopes of the Atlas Mountains and various lesser Saharan hills and plains, the Saoura runs into a great lifeless salt flat far downstream from Beni-Abbès. Upon my arrival in 1972, the wadi had been dry for several years, owing to the combined effects of dam construction in Morocco and the prolonged pan-Saharan drought. Dunes had appeared in the wadi bottom, and no one could say with confidence if a flood of sufficient magnitude to flow the full length of the Saoura and clear the debris would ever be seen again.

Once a more or less annual event, the Saouran flood had failed for seven years before the drought broke in November 1973. The skies opened up over the entire northwest Sahara and in three days 1.6 inches of rain fell at Beni-Abbès; the average annual rainfall in recent years had been half that. On the fourth day, just as the storm cleared, the wadi began to flow. In a few hours it grew from a trickle to a rapid river that remained impassable for four days and took another week to stop altogether. The people came down to the river bank every day and stared at the swirling waters, saying little. I could hardly guess what thoughts the long-awaited spectacle inspired except that the face of a man or woman standing alone would occasionally erupt into a huge smile. The younger children were openly thrilled. They had never seen anything like the rushing wadi, had never seen a creek or a pond. They deliberately provoked little collapses of the sandy banks, springing back with shrieks of fear and delight before inching forward to do it again.

The storm brought many changes. When the river subsided, the people did what North African people have done for centuries: they hurried to plant wheat in the wadi bottom. On the hamada, bare gravel suddenly blossomed as a host of tiny opportunistic flowering plants ran through their rapid re-

productive cycles. Gray-brown perennial bushes put on a burst of green growth. And gerbils, as opportunistic as the plants, quickly came into reproductive condition.

Each of the habitat types around Beni-Abbès has its particular species of gerbils: two, of the genus *Gerbillus*, are confined to the erg and other very sandy places; another occurs primarily in the mixed habitat on the boulder-strewn cliffs rising from the wadi to the hamada; and a fourth is found in relatively damp sites, primarily in the wadi. The rarest and most unusual gerbil, the fat-tailed insectivorous *Pachyuromys duprasi*, is confined to the hamada, as is *Meriones crassus*, a shy species that prefers to burrow where there is no vegetation.

The two species that I studied most extensively are the Libyan jird and the fat sand rat. The fat sand rat, *Psammomys obesus*, is essentially restricted to the wadi. The Libyan jird, *Meriones libycus*, occurs in both the wadi and the hamada, and is the gerbil most likely to invade gardens and towns.

The social systems of all the Saharan species appear to be basically the same, although there are important quantitative differences in home-range size, aggressiveness, and the frequency of social interactions. (The social systems of several gerbil species in Asia and sub-Saharan Africa appear to be quite different.) In all Saharan species studied, adults occupy separate burrows. Only a mother with her nurslings or a recently weaned group of immature littermates can be found residing together amicably. Adult females occupy relatively small and exclusive areas that overlap little or not at all. Males, by contrast, travel widely, repeatedly visiting the several females within their home ranges, and the ranges of different males generally overlap extensively.

In a population of Libyan jirds on the Hamada du Guir, for example, each female lived for months on end in a single *daya*, a patch of bushes surrounded by utterly bare desert. In the richest *daya*, covering 23 acres, five adult females occupied domains of 1.5 to 10 acres, each overlapping slightly so that a few bushes might be shared without apparent hostility. Several males regularly toured the whole *daya*, and these same males repeatedly visited *dayas* occupied by other females, sometimes crossing one and a half miles or more of bare terrain in order to do so. This hazardous life style increases their exposure to predators and results in a much shorter life expectancy for males than for females, but the risks cannot be avoided if a male is to achieve genetic posterity in reproductive competition with his fellows.

Gerbils are predominantly seed eaters whose main adaptation to desert conditions is a stringent water economy. Certain species have evolved to exploit an abundant water supply that is inaccessible to most desert denizens: the succulent leaves of saltbushes. These constitute the exclusive diet of the widespread fat sand rat. The plump leaves of the various Saharan saltbush species (members of the spinach family) contain plenty of water, but as a water source they are of no use to a thirsty traveler, for their water is far saltier than seawater. The fat sand rat's favorite food near Beni-Abbès, for example, is souït (*Suaeda mollis*), a bush whose leaves commonly consist of 90 percent water by weight. Yet even camels who feed on souït must frequently find a fresh well from which to drink, while those who feed on less salty desert plants may pass the entire winter without a drink. Analyses of souït leaves from the study area showed them to contain 12.2 percent sodium by dry weight. Despite souït's staggering salt load, fat sand rats thrive on it. They manage this with the aid of the most powerful kidneys known to science. All gerbils conserve water by producing highly salt-concentrated urine, but fat sand rats do this more effectively than other species, possibly because their kidneys have larger Henle's loops—a hairpin-shaped portion of the nephron tubule that enhances water resorption.

Sodium is not the only ingredient that prevents other animals from feeding on saltbushes with impunity. The leaves also contain excessive amounts of oxalic acid, a substance that has been responsible for mass deaths of sheep grazing in arid regions in Australia where saltbushes predominate. How the fat sand rats detoxify oxalic acid, which they consume in quantities that would be lethal for a much larger animal, remains unknown. Concentrations of saltbushes grow along the wadi, particularly where there is some subterranean trickle of fresh water from higher land. My main fat sand rat study area was the now abandoned oasis of Ouarourout, a little patch of green about four miles up the Saoura from Beni-Abbès. Some date palms

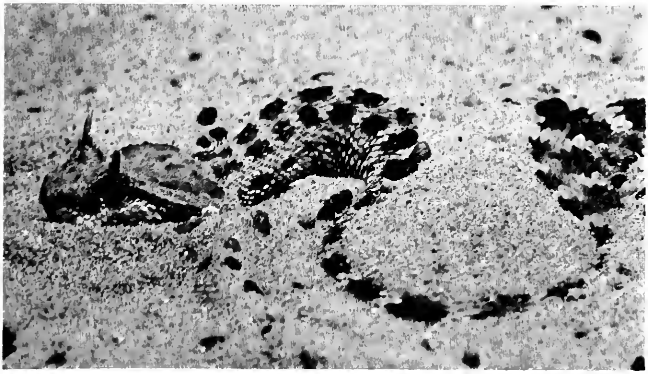
The hamada, top, and the wadi, bottom, are distinct habitats; each supports species of gerbils.
The Wadi Saoura is a part-time river; the pools resulted from the first heavy rains in seven years.

Martin Daly

Kenneth Noriach

Clem Haagner, Bruce Coleman

Steinhart Aquarium (Tom McHugh, Photo Researchers)



endure, along with a garden that produces carrots, long white radishes, beans, and a few fruits. The old gardener walks to his plot each day from Beni-Abbès.

At little oases without springs, such as Ouarourout, the subterranean water provides an optimal sand rat habitat of dense saltbush. Fat sand rats are a particularly attractive species of gerbil for the behavioral scientist because they are easily observed. They are diurnal and their diet allows them to be relatively sedentary, whereas other gerbils forage widely by night.

Adult female fat sand rats prefer to find a full-sized saltbush, dig a burrow under it, and stay as long as the food lasts. A female who has found a good locale may gestate and raise a litter of pups over the course of two months without once roaming more than about thirty feet from her burrow entrance. She will then move a short distance to a new burrow and repeat the process, sometimes continuing to visit her weaned litter to cut and hoard leafy branches for them.

The horned viper, above, lanner falcon, right, and fennec (the smallest of all foxes), far right, are all gerbil predators. A small Gerbillus *gerbil has dug its burrow, below, in a clump of the saltbushes it feeds on.*

Roland Vernet

The fat sand rat's dietary specialization influences all aspects of the animal's biology. Typical seed-eating gerbils only eat some 5 to 10 percent of their body weight daily, but must cover large distances daily in search of the tiny, scattered, energy-rich morsels. A fat sand rat eats about 100 percent of its body weight daily, but can collect an entire day's ration in a quarter-hour's labor near home.

One consequence of the fat sand rat's feeding habits affects the development of the pups. The chronology of development in this species is very like that of the closely related Libyan jird: pups are born naked and blind and become furred in the first week; their first tentative nest departures occur at eleven to thirteen days of age and the first sorties from the natal burrow at four to five weeks; the eyes open at two weeks of age; sexual maturity is attained at three months. These developmental schedules are so remarkably alike that a single dis-

Roland Vernet

crepancy comes as a surprise: a fat sand rat's incisors first pierce the gums at three days of age, fully a week before the same event occurs in the Libyan jird and other gerbils, and the fat sand rat begins to eat solid food a week earlier.

This difference can be explained by considering respective maternal time budgets (the males play no parental role). For most gerbils, seeking food is the most time-consuming activity. When a nursing mother finds an energy-rich seed or insect larva many feet from her burrow, she gulps it down in a moment. But for the fat sand rat, the finding and collecting of food demand only a few minutes a day; food is always brought to the home burrow and it is the actual *eating* that is laborious. Tests on captive animals showed that a lone fat sand rat can easily spend more than four hours a day just chewing and swallowing, pauses not included, while a like-sized rodent eating high-energy foods such as seeds spends less than twenty minutes on ingesting food. When there are pups to feed, the fat sand rat's workload is increased. By three weeks of age, a litter outweighs its mother and the pups also outeat her relative to body weight. The result is selective pressure toward early self-feeding in the young.

Another consequence of the fat sand rat's dietary specialization is extreme aggressiveness. In captivity, most gerbils can be housed in pairs for the purpose of breeding, but if a pair of fat sand rats are left in a cage, one or both will soon be killed. In the field, fat sand rats live at higher densities than any other Saharan gerbil, but their "colonies" actually consist of mutually hostile individuals brought together by a local concentration of leafy food.

Yet that food distribution also appears to be the ultimate cause of the hostility. A fat sand rat's food source is spatially confined and highly visible, facts that make it economically defensible. In other words, the fat sand rat's practical strategy is to defend a feeding territory, maintaining exclusive rights to an adequate food supply, something that is impossible for a wide-ranging gerbil dependent upon inconspicuous, unpredictable seeds. Adult female fat sand rats are vigorous defenders of their small feeding territories and rarely range beyond the areas they defend. Because males range more widely, attempting to breed with several females, it is more difficult for them to keep an area free of intruders.

The spatial distribution of fat sand rats is thus like a miniature version of that described earlier for the Libyan jird. A female fat sand rat's domain may be as small as a hundredth of an acre, at least two orders of magnitude smaller than the jird's. Total exclusion of intruders is clearly a more attainable goal for the fat sand rat. And while the male fat sand rat may range over two or three acres, the male jird travels much farther and does not even attempt to drive other males completely from his range, although he may attack and chase them. When a female jird nears estrus, a male may attempt to guard her from other males, rather than guard a breeding territory.

Many aspects of the biology of the two species are similar. In both, pregnancy lasts twenty-five days and is prolonged to about thirty five if the mother is nursing a previous litter. When the pups are fully weaned, the mother usually leaves them in their natal burrow and takes up residence elsewhere. The weanlings' tendency to remain together gradually diminishes over several weeks, and by

two months of age each pup is likely to occupy a separate burrow. They remain fairly close together within their mother's former territory, but direct encounters are rare. In the next month, the juveniles usually part company once and for all, striking out individually. One may turn up 160 feet away in one direction, another more than half a mile away in a different direction.

Few survive to join the breeding population. Those juveniles that cross the barrier to adulthood may reasonably expect to survive for several months more, especially if they are females. At the little oasis of Ouarourout, for example, there were seven resident adult female fat sand rats in January 1974. Three months later, six of them were occupying the same territories, and the seventh had been replaced by a new female. That isolated little population was breeding steadily throughout the winter, producing about ten female pups per month; yet just one new adult female established herself during the three months. Similarly, a large hamada study area of some three and a half square miles contained ten adult female Libyan jirds in November. Four months later, nine were still present and there were no new females at all. In both species, the male population turned over faster than did the females.

The fate of the missing juveniles could seldom be established, but there is no shortage of potential predators. A fox's den on a rocky slope was littered with dozens of skulls of the tiny gerbil that favors that habitat. In the wadi, burrows are often extensively excavated by jackals. Other mammalian predators in the vicinity are Marguerita, or sand, cats and skunklike zorillas.

Birds are probably more important predators. A pair of rough-legged buzzards nested near one of our study areas and a pair of Lanner falcons near another. A migratory lesser kestrel once killed a fat sand rat in one of our mesh traps, and an eagle owl disrupted the study the next year by discovering the same trick and killing three trapped jirds in a single night. Brown-necked ravens and barn owls also frequented our gerbil sites, and we were amazed that the sparse rodent populations could support such a variety of predators.

Probably the most important predators of all are snakes: the sand viper of the erg and the horned viper of the hamada. In the research center in Beni-Abbès, sand vipers were maintained and exported for study by French herpetologists. The animal caretaker fed them the small *Gerbillus* gerbils. The gerbils never showed the slightest alarm or evasive action when placed in a cage with the reptilian predator. They hopped about, investigating the cage, until the snake struck.

One morning I trapped a house mouse in the kitchen and thought that by offering it to the viper I would save a gerbil. The sluggish viper oriented toward the mouse and flicked its tongue twice. The mouse attacked! Seizing the viper's head in both forepaws, the little rodent dispatched the foot-long snake with a single bite through the brain and then calmly set about eating its victim. No doubt the mouse would have been the loser had the viper been well warmed up. I was left wondering why the gerbils exhibited no response to the snake.

One hardly sees a viper in the winter, but in March and April, they become active as the northwest Sahara heats up. When snakes begin to be a threat, when the fierce radiance of the sun makes outdoor work a burden, when sandstorms of several days duration become frequent, then that is a good season to leave the Sahara. I have not remained in Beni-Abbès past early May, and the gerbils have been left to survive the severe Saharan summers unobserved. □

The leaves of the soüit bush contain 90 percent water by weight, but the water is saltier than seawater. To eliminate this salt, the fat sand rat produces highly salt-concentrated urine.

Roland Vernet

How to Catch a Fish in Three Seconds

Photographs by Bo Göran Backström

The osprey is also known as the fish hawk, with good reason, for fish are all this raptor feeds on. Flying slowly over the water, the osprey scans for fish swimming near the surface. Having spotted a target, the bird folds its wings and stoops into a swift dive. Its aim is normally sure, and the fish is impaled by the hawk's gripping talons. The osprey lifts its prey out of the water with ease, then flies to a favored perch to dine. A 20-year-old photographer sat in a blind on Lake Glan, Sweden, for 200 hours in order to capture this remarkable fish story on film.

Paleopathology in Peru

by Marvin J. Allison

Studies of ancient Indian mummies indicate that some infectious and industrial diseases are more than two thousand years old

"In the beginning of the year 1560 I had to go to Spain, and I went to the House of Polo Ondegardo, the Corregidor of that city [Cuzco], to say goodbye to him in preparation for my trip. Among other favors he did me at that time was when he told me, 'Since you are going to Spain, go into that bedroom, you will see some of your own people that I have recently discovered; so when you arrive there [Spain] you will relate it.' In the bedroom, I found five bodies of the Inca nobility, three men and two women. The Indians said one was Viracocha, who showed his age as his head was as white as snow. The second was said to be the great Tupac Inca Yupanqui, great-grandson of Inca Viracocha. The third was Huayna Capac, son of Inca Tupac Yupanqui and great-great-grandson of Inca Viracocha. The last two did not seem to have lived so long; even though they had gray hair, these were fewer than those of Viracocha. One of the women was the queen Mama Runtu, wife of Viracocha. The other was the noblewoman Mama Ocllo, mother of Huayna Capac, and it is noteworthy that the Indians had them together after death, husband and wife, as they lived in life. The bodies were intact; not even hair, eyelashes nor eyebrows were lacking. They were dressed as during life, the royal fringe on their heads, and were seated as in the Indian custom with their hands crossed over their chests, the right over the left, eyes down as if looking at the ground.

"Father Acosta [a chronicler of Peru], speaking of one of these bodies (he also saw them), says in his book, 'The bodies are intact and well covered with a certain wax so they appear alive. Their eyes are made of small bits of gold so skillfully placed that the lack of the real ones are not noticed.' I confess in my carelessness I had not looked so close since I didn't expect to write about them. Also, I didn't notice the wax because they looked so real, just as the holy father stated."

This description, one of the earliest direct observations of ancient Peruvian mummies, comes from the *Royal Commentaries* of Garcilasco de la Vega, a chronicler of the Spanish conquest of the New World. Garcilasco, known as El Inca because he was the son of a conquistador and an Inca princess, was born in South America and spent his old age in Spain writing his histories. Later writers claimed that Peruvian mummies were preserved by elaborate embalming methods, but Garcilasco specified that bodies were simply dehydrated in the open air, without the addition of salt or other preservatives. For centuries, Peruvians had used this simple method to preserve meat.

Today, by studying mummies, it is possible to document the cycles of disease in population groups that lived two to three thousand years ago. Knowledge of the history of a disease points the way toward reducing or eradicating it. Unfortunately, mummies can be found today only in a very few areas with appropriately dry climatic conditions: Egypt, the southwestern United States, China, the Aleutian Islands—where bodies, sewn very tightly in skin, are entombed in caves—Chile, and Peru. In Peru and Egypt, researchers are not limited to the mummies of a few nobles, such as those described by Garcilasco, but can study members of all social strata.

Since 1970 I have directed a multidisciplinary study to evaluate health conditions in a population that has lived in a relatively stable environment—the desert valleys of western South America—for some 5,000 years. Participants have included American and Peruvian archeologists; anthropologists; radiologists; anatomic, oral, clinical, and neuro-pathologists; chemists; immunologists; an otologist; and students from many disciplines. We are studying pre-Columbian and colonial mummies, looking at such genetic markers as blood groups, bones, teeth, and making comparisons with the area's contemporary population, in order to trace the history of human diseases and migrations and learn how the environment and social mores changed the appearance of particular illnesses.

As the site of our study, we chose the state of Ica, about 180 miles south of Lima. At Ica there was a new museum with a staff capable of the necessary archeological fieldwork, and the dry climate—Ica's entire coast is one of the world's driest deserts—insured well-preserved mummies.

Ica's coast and mountains have been the home of various cultural groups. The people of the Nazca culture flourished from 100 B.C. to A.D. 800 on the southern coast's desert plain, which they decorated with huge figures whose designs can only be fully appreciated from the air. The Nazca style probably succeeded the Paracas culture of

This unwrapped mummy—a ten-year-old girl of the pre-Columbian Huari culture—was found buried with a parrot at its feet.

Marvin J. Allison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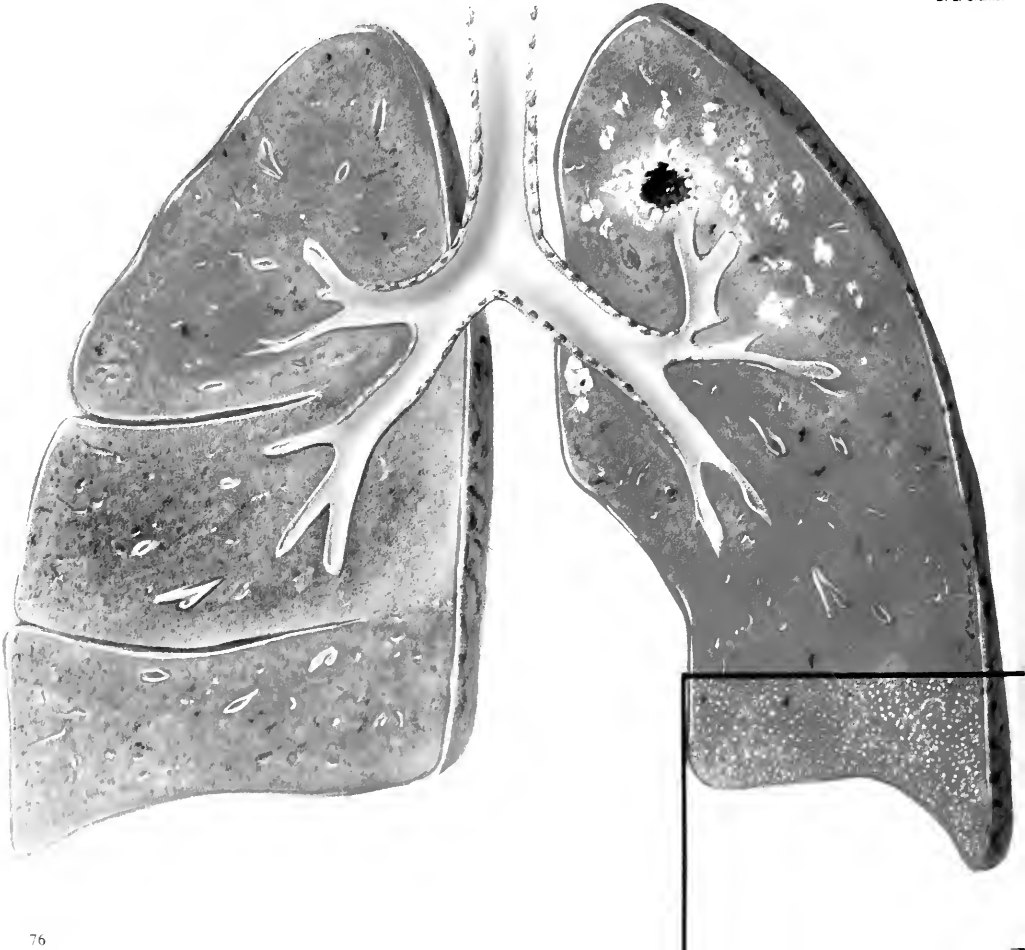
the Pisco Valley; the unique animal imagery in Paracas and Nazca embroidered textiles is reflected in Nazca plains figures.

The Huari empire—which from 800 on expanded all over southern Peru—conquered the Nazca region but allowed its wooded, irrigated, intensively farmed river valleys to flourish. These arable river valleys—twenty-five miles long and a few miles wide—were centers of civilization. Their cities and burial grounds were built in the bordering desert. The Huari empire began to break up about 1200 and many city-states were peacefully absorbed by the Inca empire, through mergers for economic or trade reasons. Although the Inca imposed their language and religion on an annexed region, they did not interfere with local cultures. Ica thus remained home to warrior-farmers who cultivated corn, potatoes, fruits, beans, manioc, and quinoa, a high-protein grain. The Indians' sources of animal protein included dogs, camelids, guinea pigs, ducks, and possibly turkeys and doves. After Pizarro conquered the Inca, food was in short supply. Civil war raged, and from 1540 to 1552, the country was in turmoil, north pitted against south. The native population was decimated by war, smallpox, and probably measles.

Today the state of Ica is geographically much as it was 5,000 years ago, except where river courses have been changed by earthquakes or other natural disasters. When we hunt for sites to excavate mummies, we look for the cemeteries of the old river cities. Each year of our study we have ex-

In colonial Peru, native miners often suffered from respiratory diseases. The middle lobe of the lung at left shows pneumonia. The lung at right shows two different kinds of tuberculosis: chalky lesions in the apex and, below the black line, miliary tuberculosis, a diffusely seeded variety.

D. L. Cramer



cavated two to three cemeteries in one valley, usually obtaining fifty to seventy-five mummies.

Initially, one of the striking findings of our research was that, in more than 5,000 years, the height of the people of Ica had not changed appreciably. Modern rural inhabitants of mixed blood are still about the same size as their Indian ancestors. Modern Europeans, however, are considerably taller than their ancestors: museum visitors often wonder aloud how grown men could have fit into those tiny suits of armor. Size is probably closely related to nutrition, which in Ica has not greatly improved. The typical mountain meal is still dried potatoes, beans, corn, hot peppers, and perhaps some onions and sweet potatoes.

After observing the mummies' height, we then wanted to determine their age at death. In most of the world today, the average life span is less than forty years, except in areas where improved health care and preventive medicine have raised the life expectancy to past the age of seventy. In pre-Columbian Ica populations, 27 percent of the people lived past forty, compared with only 12 percent in colonial times. Both before and after the colonists' arrival, 50 percent of all children died before the age of ten. The sole exception was a 5,000-year-old coastal people who lived mainly on seafood—a very high protein diet; among this group, only 35 percent died before the age of ten. Male children tend to die more frequently—in pre-Columbian times, under the age of three; in colonial and modern times, before the age of one.

Contrary to findings concerning early European populations, women in Peru have outlived men in both ancient and modern times. Women had a special advantage in colonial times, when the Spaniards, adopting the Inca idea of mita, or forced labor to pay taxes, conscripted Indian males to work in silver mines. Women probably also lived longer because they had relatively few pregnancies; children were not weaned until they were two or three years old.

We were able to draw a picture of childhood health by studying mummies' bone scars, marks of arrested growth. In children, diseases of relatively short duration and periods of starvation will temporarily halt bone growth, but bone calcium is still produced, resulting in scars, or Harris lines, on, for example, the long bones of the legs. Since these lines are visible under X-ray as cross striations of the bone, we could roughly calculate the age at which such lines occurred, and by comparing mummies with contemporary adults in Ica, roughly estimate ancient peoples' state of health during the first sixteen years of life, when greatest growth occurs.

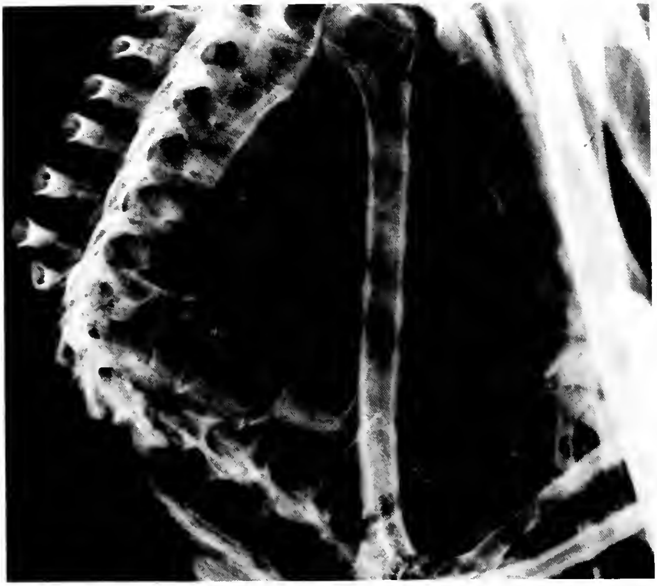
We found that 5,000 years ago the healthiest children lived on the coast, benefiting from a high-protein diet of fish and shellfish. Life in a farming village in the mountains probably meant less protein and closer quarters, which facilitated the spread of infectious disease and created sanitation problems. Shortly before and after Columbus, however, people from mountain cultures seem to have had healthier childhoods than people from coastal cultures. This may be related to the presence of malaria on the coast, but not in the mountains, until about thirty years ago. Certain evidence suggests that malaria was present on the coast in pre-Columbian times: many coastal Indian mummies show a peculiar bony lesion of the skull, usually caused by chronic anemia, which could be related to malaria. But whether malaria arrived in South America with the Spaniards, who may have contracted it while fighting the French in Italy, remains in dispute.

The problem of malaria's presence in pre-Columbian America remains unsolved, but we have established that in Peru tuberculosis is 3,000 years old. After the arrival of Europeans, tuberculosis decimated the native peoples of both North and South America. Introduced into a new population, tuberculosis remains essentially a pulmonary disease; the patient dies before the infection can spread to bones, joints, lymph nodes, kidneys, or genital tract. The severe

Marvin J. Allison

This mummy's broken leg healed badly, so that the bones fused. Although he could walk, the man could not rotate his healed leg.

Marvin J. Allison



Left, the spine of a pre-Columbian woman who once suffered from Pott's disease (tuberculosis of the bone) can be compared with a normal spine, below. With her spine missing two vertebrae, the ancient Peruvian would have been severely hunchbacked.

D. L. Cramer

tuberculosis seen in North American Indians led to the general medical belief that the disease was newly introduced. But in a Nazca culture grave, dating from 700, we found the well-preserved mummy of an eight-year-old boy, probably the son of a local *curaca,* or "chief." The boy had died of a massive blood-borne form of tuberculosis known as miliary tuberculosis, but he also showed evidence of long-standing bone and kidney infection. For some time prior to his death, he had not been able to walk, and an adobe seat—molded to fit his limbs and fitted with a thick cloth cushion to make him comfortable—had been made for him.

We have since found a number of other individuals with similar types of disease, proving that among pre-Columbian Indians in South America tuberculosis was a fairly common illness, probably much like the disease in white Americans before the use of antibiotics. The severe tuberculosis observed in colonial times probably reflected drastic changes in the Indians' way of life. Among Latin Americans today, other than the affluent minority who live in twentieth-century comfort in major cities, tuberculosis is still a major cause of death, along with other respiratory diseases. In pre-Columbian times, pneumonia was the primary cause of death.

Gastrointestinal disease is extremely common throughout Latin America and probably has been since pre-Columbian times. In the past, researchers have examined the fecal material of mummies only for ova and parasites and have found a number of intestinal worms and their eggs, including the first recorded case of hookworm in pre-Columbian America, in a mummy dating from about 900. Because methods of identifying different bacterial proteins are now available, paleoserologists can study mummies for the presence of a wide variety of intestinal bacteria, and then look for the diseases that they might produce. In this manner, researchers found salmonella antigens that suggested the presence of typhoid fever.

Immunological methods have also enabled us to use blood groups as a means of identifying blood relations within the same cemetery, tracing family groups to valley groups and valley groups migrating from one valley to another, driven out by invaders or lack of resources. We use red and white cell antigens, genetic markers easily

identified in populations. The ABO red cell markers have been used before to establish blood relationships among tribes and racial groups; with Rh and other subgroup systems, they are currently used in forensic medicine to establish possible paternity. This ABO system is one of many red cell systems that have been successfully applied to paleoserology; recently we have added fifteen to twenty genetic markers of white blood cells. These two groups can be used in paleoserology because they are distributed in most body tissues, including muscle. When the results of tests for these genetic markers in mummies are combined with archeological and bone evidence, we can suggest blood relationships among individuals in a given cemetery—very useful when studying peoples with no written language.

In the Pisco Valley, forty-two miles north of the city of Ica, we applied these paleoserological techniques to a colonial (1580–1650) Ica cemetery. We excavated sixty-seven mummies, not counting five newborns buried with their presumed mothers. Fifteen of these adults were urn burials, many with clothing, ceramics, and other artifacts characteristic of the Ica culture. The remaining fifty-two bodies, accompanied mainly by Inca artifacts, were wrapped in cloth, an Inca burial custom. But the long, narrow strips of loose-weave cloth were characteristically Ica in color and style.

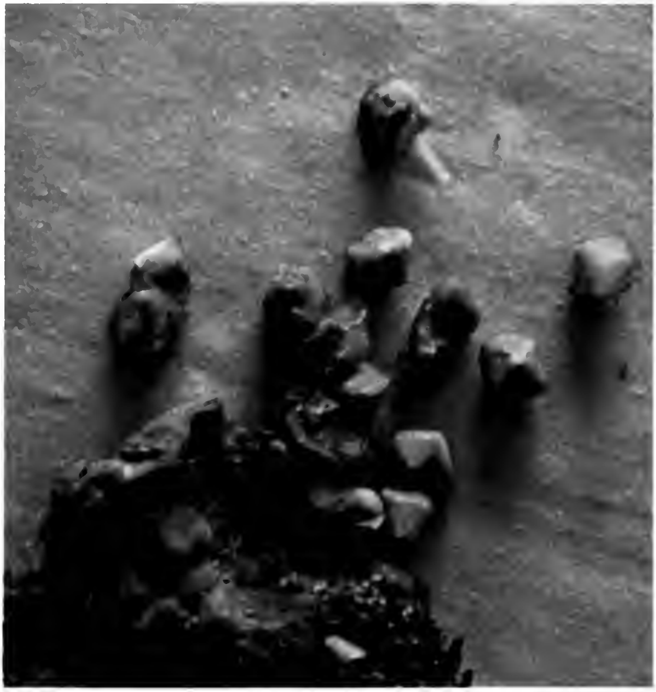
The fifteen urn burials included four individuals classified as blood group A: two of these were females—a thirty year old and an eight year old—both wrapped in the same kind of cloth. Since these two were also the only ones who had two similar white cell antigens, HL-A2 and HL-A9, they may well have been sisters.

Another tomb contained a woman in her midthirties with a newborn baby. Both individuals were group A and had the common white cell markers HL-A9 and W19, strong evidence that they were mother and child.

Sometimes antigenic relationship told us more than burial practices. Among the urn and cloth burials there were only three individuals with the white cell marker HL-A3: a 56-year-old female urn burial, an 18-year-old female cloth burial, and a 6-month-old female cloth burial. These three females were all blood group A. The two cloth burials also had a W19 marker as well. Carbon-14 dating and the presence of Ica art styles showed the urn burial to be the oldest, dating from about 1580. The two cloth burials had mixed Ica and Inca colonial artifacts, suggesting possible intermarriage or cultural readaptation within this particular group of genetically related individuals. Archeological blending of Ica and Inca cultures appears in colonial ceramics and is probably associated with interbreeding. We also considered the presence in the colonial cemetery of HL-A3 and HL-A12, two common European markers found very infrequently in pure Peruvian Indians, to be evidence of miscegenation.

Such studies will eventually enable us to trace migratory patterns

Marvin J. Allison



Gallstones, often found in mummies recovered in Chile, spill from a gallbladder. The Chilean diet of high-cholesterol jack beans may have caused this condition.

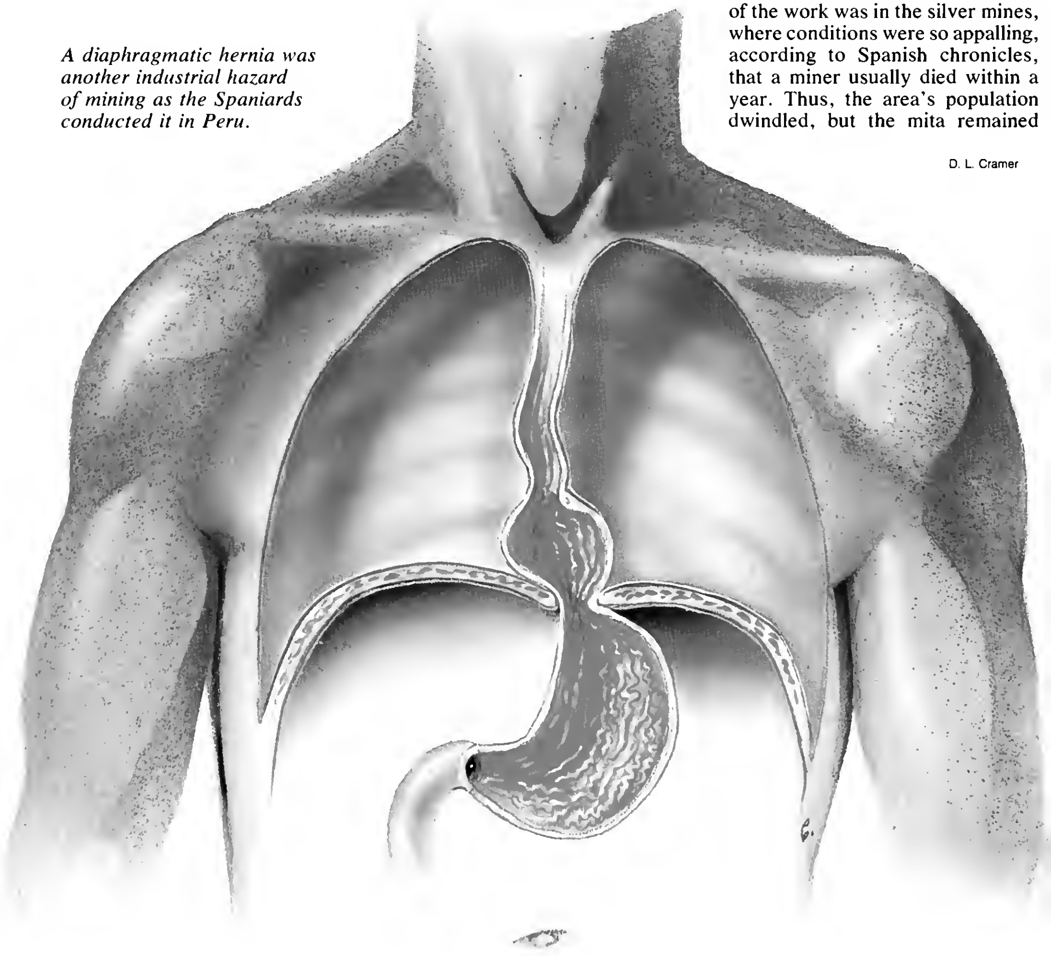
When the Nazca phase developed from the Paracas culture over a thousand-year period, this cultural development did not result in a change in blood groups. The Huari and the Ica, however, were invaders who introduced genetic changes. In pre-Columbian Indians, we have encountered the B group and AB combinations. We have found that mummies from the Huari empire are more than 20 percent AB. As early as 5,000 years ago, the inhabitants of coastal Peru had all the blood groups, but during the time of the Inca, the dominant group—90 percent of the population—was O, with a few A individuals completing the picture. Since the Inca came from the south,

and since most pre-Columbian Chileans we have studied have been O, these dominant people presumably came from southern valleys. All AB and B individuals were driven out or killed, but the reason for this remains unclear.

A major invasion, such as that of the Spaniards, can not only change blood type but can also completely disrupt a people's way of life. Unlike the French, English, and Americans, who slaughtered the North American Indian population by various brutal means, the Spaniards were more interested in preserving South American Indians as a source of cheap labor. The conquerors retained most aspects of the administrative system of the Inca empire and used it for their own ends. Theoretically, Indian slavery was outlawed in the New World soon after the Spanish conquest, and Indians in Peru—as in Cuba, the Antilles, and in Mexico—were considered subjects of the king of Spain. In reality, the Indians remained in separate communities, governed under the Inca system as adopted by the Spaniards. Indian officials friendly to the conquerors enforced Spanish law or whim on their own people. The most damaging burden was the mita, or tax in the form of labor, which the Inca exacted from each village or region. Under the Spaniards, the mita might require, initially, that an able-bodied male villager work three months of the year for the Spanish crown. Most of the work was in the silver mines, where conditions were so appalling, according to Spanish chronicles, that a miner usually died within a year. Thus, the area's population dwindled, but the mita remained

A diaphragmatic hernia was another industrial hazard of mining as the Spaniards conducted it in Peru.

D. L. Cramer



This modern Peruvian was born with a dislocated hip, but the movement of the leg in walking has formed a new socket. Similar formations have been found in pre-Columbian mummies.

the same, so that the allotted three months of work lengthened into six months or a year or more.

Our studies of colonial burials have enabled us to evaluate the horrific descriptions by numerous chroniclers, including Father Acosta, of the Indian's life under the heel of the conqueror. In 1974, we excavated a colonial cemetery in the Pisco Valley, one of Peru's twenty-four river valleys, which begin in the Andes to the east and flow west to the Pacific. Most of these valleys have water three to four months of the year, when there is rain in the mountains. The Pisco Valley, fed by snow from a melting glacier, is exceptional and important because its river flows all year round. In Inca and colonial times, the valley was the site of a road linking the mountain and coastal road systems. During the colonial period, the valley provided access to several important mines, including the mercury mine at Huancavilica.

The valley must have been much traveled, offering opportunities for close contact between whites and Indians. But for nearly one hundred years after the conquest, there is no evidence in the cemetery that Catholicism touched the native population. In seventy-two tombs dating from 1580 to later than 1630, we did not find a single European religious article. The old ways of burial persisted; in one example, a female llama had been ceremonially buried as a woman would be—with loom, thread, and needle case. In spite of the chronicles repeated declarations that the natives were extensively proselytized, our evidence indicates that the Spaniards were more interested in the Indians as laborers than as catechumens.

In this valley we do have direct and indirect evidence of the Spanish presence in a number of other ways. The ratio of male to female adult burials dropped to one in fifteen, probably the result of the mita. Males were sent to the distant mines where they died; at least, they left and never returned. Males who were found buried in the valley generally had physical defects rendering them unfit for labor. Food and artifacts were scarce in the graves, and the clothes of the people were patched and repatched. Their connection with silver mining was inferred from numerous small lumps of silver, shapeless and rough as if the molten metal had fallen on the ground or intentionally been poured there, to harden and later be slipped into a pouch or bag. Some pieces still bore the marks of sand.

The records of colonial mistreatment of the natives were confirmed when we discovered in the colonial cemetery a nearly 500 fold increase in fractures. The mummies nearly

all had multiple fractures, often in different stages of healing. One woman had thirteen broken ribs in all stages of healing, indicating systematic battering. Most common were fractures of ribs and clavicles, perhaps the result of Spanish masters kicking kneeling Indian servants, as illustrated in one Peruvian chronicle dating from about 1610.

Some fractures undoubtedly occurred in the mines, where accidents were frequent. We studied some people who were involved in colonial silver mining about 1600, living on what was originally an encomienda (a temporary grant of land, with its inhabitants and produce, that the Spanish king bestowed on a conquistador for meritorious service) covering Peru south of Arequipa and all of present-day northern Chile. The encomienda's owner lived in Arequipa, and his property was run by an overseer who supervised eight farms, a store, an inn, grazing land—with cattle, goats, sheep, and pigs—silver mines, and a refinery, as well as a dried-fish industry. He oversaw about twenty Spanish employees, including several priests and a miner, twenty to twenty-five Negro slaves, and an unknown number of tax-paying Indians. The Spanish colonial system in the Americas was entirely geared to mining: aside from its own mining, the encomienda produced food that was sold to feed miners in Potosi, in present-day Boliva.

Mining as conducted by the Spaniards in Peru killed more Indians than all disease epidemics combined. In 1629, 80,000 Indians were mustered for the mines, but forty-five years later, only 1,674 could be found in all of greater Peru. By 1700 many of the silver mines had closed for lack of workers. These mines began at an exposed mineral vein and followed its course, widening and narrowing or branching as the vein branched. A mine was sealed by a door to control the quantity of ore coming out and to prevent theft. Shoring was usually limited to a few branching trunks or, because wood was scarce, to a rough stone wall. As the mine deepened, the miners were often obliged to climb 500 to 1,000 feet on woven cowhide ladders, carrying fifty-pound sacks of ore on their backs. They worked in groups of three; the top man had a lighted candle tied to his thumb.

The ore, black like coal, was extracted with heavy iron or bronze bars, and the air was thick with dust and metal vapors. Since there were no air shafts, most mines closed prematurely when the air became insupportable. Cave-ins and falls were daily occurrences.

Chemical poisoning from lead or mercury was another hazard: in many mines, the miner or his family refined the ore, initially skimming silver off the top of molten lead. In 1566, mercury, used in Europe since Roman times to extract silver from low-grade ore, was discovered in Peru. After 1571, the Peruvian miner used mercury in refining and further shortened his already brief working life.

In all fairness to the Spanish government, laws to protect the miner were very quickly enacted, but their enforcement was questionable. Ordinance nine, decreed by Francisco de Toledo, a viceroy of Peru, states that the owner of a distilling operation for refining silver must personally open the still. However, owners often lived two hundred miles from their mines. In 1634, a medical school was founded at San Marcos University; ironically, the first chairs in medicine were funded from revenues of the mercury mine in Huancavilica, Peru, where numberless Indians died.

Silver miners also suffered from black lung, the first industrial disease in the Americas. We studied twelve mummies of miners, all of whom had black lung disease. Their lungs contained silver mixed with copper and iron as well as silica, which causes silicosis. Silicosis weakens the lungs and predisposes patients to pneumonia and tuberculosis. Of the twelve, ten had died of pneumonia and three seemed to have had tuberculosis. Several miners had enlarged hearts, probably due to lung disease, and one had a diaphragmatic hernia. The presence of mercury in their bodies helped us date them as living after 1571, when this substance became common in refining.

Another disease that can be considered occupational is osteoarthritis, or rheumatism, which may result from repeated stress or trauma of the articular cartilage. We found lesions of this disease in the vertebral columns of pre-Columbian and colonial Peruvians, as young as the late teens. By age thirty, many individuals showed advanced lesions, suggesting that they carried heavy loads. In modern-day Peru the carrying of heavy loads is still common. A few years ago, I saw an Indian porter in Cuzco serve as a moving van: he carried a dining room table, six chairs, and a small china closet on his head for several blocks.

Peruvians' backs may have always hurt, but their toothaches have grown progressively worse since they first took up farming. Five thousand years ago, coastal Peruvians, who opened clam or oyster shells with their teeth and ate the sea's sandy products, had worn their teeth to the gum by the age of twenty-five. But they had very few cavities and fewer root abscesses. Village life, which accompanied the introduction of agriculture, saw an increase in dental problems: cavities, tooth loss, and bone infections of the jaw multiplied. Dental caries were common in Inca children, who consumed no candy or soda but ate a high-carbohydrate diet. Yet we have no evidence of any type of dental practice in ancient Peru. Today, Peruvians have dentists, and tooth erosion and tartar deposition seem less. But like contemporary people in general, modern Peruvians have considerably less protective enamel, which may be why dental disease is still high.

All of these findings, while constituting a bare beginning, may serve as a base line from which we can measure the role of modern medicine in changing disease patterns. In Peru, we have not yet discovered any new diseases, but we have been able to piece together some of the history of human diseases, many of which have been described only within the last two hundred years. The Americas offer paleopathologists a unique opportunity: here is a vast land mass inhabited by a single racial group isolated for millenniums. Because of the area's well-documented history of discovery and colonization, the people and their food and artifacts can be studied before and after miscegenation. Epidemiological data from Peruvian mummies may eventually provide us with some insight into the evolutionary patterns of disease. □

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Taking the Heat

by Jerry L. Mosser and Thomas D. Brock

Microorganisms that live only in extremely high temperatures are under investigation

Microbes are so small, and their numbers usually so vast, that the biologist is overwhelmed at the prospect of sorting out how they interact with each other and with the environment. But some habitats are amenable to ecological study. These are generally "extreme" in some way—hot, cold, or very dry, for example—and so near the limits of habitability that only a few spartan species survive there. In the most extreme situations, one species may be the sole inhabitant.

Besides ecological simplicity, extreme environments have another attraction for the microbiologist—the microbes living there are interesting in their own right. They have adapted to conditions that other organisms, confined to the "normal" range of living conditions, cannot survive. By living near the physical or chemical limits of life, these microbes reveal the extremes to which evolution can be pushed.

As microbial ecologists, we have searched for microbes in a variety of extreme environments. By far the most unusual organisms we encountered are bacteria living at high temperatures. Yellowstone National Park, which abounds with natural hot habitats, was our chief hunting ground, although we also looked in some hot man-made environments. Some of the bacteria we found are new to microbiology, and their properties surprise even microbiologists familiar with the seemingly limitless adaptability of bacteria.

Because the temperature of the earth is low, it is not surprising that most microbes prefer low-temperature habitats, from about 0° to 30°C. Microbes living in humans and other warm-blooded animals are adapted to body temperatures, 35° to 40°C. By contrast, two of the bacteria discovered in hot springs live at the boiling point of water, which is 92° to 93°C at the elevation of Yellowstone National Park. (To convert Celsius to Fahrenheit, multiply by 9, divide by 5, and add 32.)

One of these, so far found only in one spring in Yellowstone, could not be grown in the laboratory. But its striking thermophilic, or heat-loving, properties could nevertheless be demonstrated, for the bacteria would grow on glass cover slips (usually used to cover specimens on microscope slides) submerged in the spring. Using the colonized cover slips instead of laboratory cultures, we learned that the bacteria took up a variety of organic compounds, all most actively at temperatures between 80° and 90°C. The bacteria obviously function well in the boiling water.

Another bacterium, named *Thermus aquaticus,* is a more common inhabitant of Yellowstone's hot springs. But it, or a close relative, has also adapted well to modern civilization—we found it in hot-water heaters in homes as well as commercial laundries. A surprisingly cosmopolitan creature, *Thermus* has been found in hot-water heaters in Indiana, Wisconsin, and England. Water heaters normally maintain temperatures of about 65° to 80°C, and *Thermus* grows best at 70° to 75°C. The bacteria seem to have no practical significance to users of the hot water.

These bacteria live in neutral or slightly alkaline water. Others, however, live in water that is not only hot but also acid, and so have adapted to two kinds of environmental hardship, either of which is enough to preclude habitation by most bacteria. Hot acid springs are not as common as hot neutral ones, but they are still widely distributed over the face of the earth. And many of them, it turns out, contain bacteria. We also found bacteria in an even more restricted hot, acid environment—burning coal-refuse piles.

Waste from coal-mining operations is commonly left in huge piles, which gradually undergo spontaneous heating due to oxidation of exposed organic matter. Frequently, the piles become hot enough to burn or smolder. They also become acidic, a result of the oxidation of pyrite and other sulfide minerals to sulfuric acid. A high temperature bacterium found here turned out to be what microbiologists call a mycoplasma—a particular kind of bacterium that, devoid of a rigid cell wall, grows as a sphere. Dubbed *Thermoplasma acidophilum* to describe its properties, this heat- and acid-loving mycoplasma is not as thermophilic as the others, since it grows best at 59°C. It is unique, though, in that it is a saprophytic mycoplasma—it obtains nutrients from decaying organic materials. Mycoplasma are usually commensal or parasitic, that is, they live in, on, or otherwise in association with higher organisms.

Thermoplasma does not seem to live in natural hot environments and has been found so far only in burning coal-refuse piles, a strange, unstable habitat. Because the burning piles must be extinguished (they are now under strict government regulation), *Thermoplasma* is probably an endangered species, perhaps the only one that will suffer from pollution control.

The bacteria found in the natural hot acid springs are even more unusual. Given the name *Sulfolobus acidocaldarius*—meaning sulfur-oxidizing, lobed bacterium of hot acid—this bacterium, as well as its relationship to its environment, was so unusual, in fact, that we studied it in greater detail and consequently know more about it than about the other bacteria. Much of what fol-

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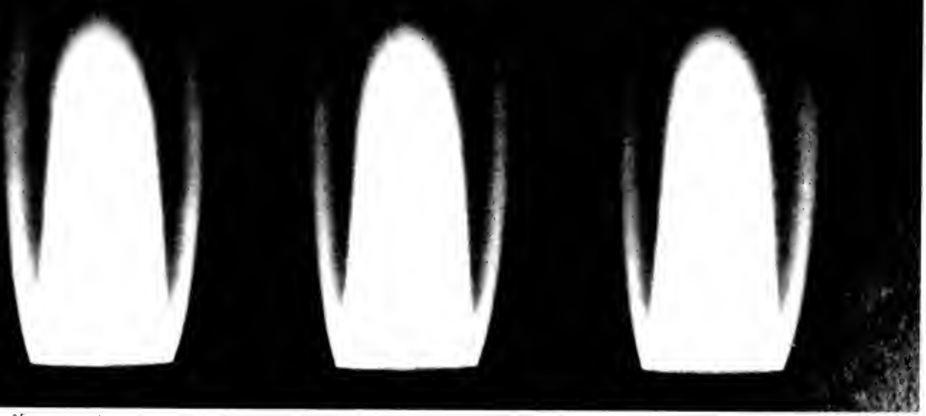


Gas: The future belongs to the efficient.

The small, bright dots in the above photomicrograph are Sulfolobus *cells attached to sulfur crystals. The cells were stained with a special dye and then visualized by means of fluorescence microscopy.*

lows is about *Sulfolobus* and its ecology.

Let us consider *Sulfolobus*'s habitat first. *Sulfolobus* lives in solfataras, a geologic term for acid regions in geothermally active areas, as in Yellowstone Park. Solfataras contain hot, acid soils and hot springs that discharge small amounts of acid water. Solfatara soils are heated by steam rising to the ground surface and contain large amounts of elemental sulfur that arises from spontaneous oxidation of hydrogen sulfide present in the steam. The high acidity of solfataras is due to the large amounts of sulfuric acid produced when the sulfur is oxidized.

Sulfolobus occurs at temperatures from about 60° to 92°C and at sulfuric acid concentrations up to 0.3 normal (pH 0.8), which is more acidic than human stomach juice. Most bacteria can tolerate an acid concentration only one ten-thousandth of this, many only one-millionth. The combination of high temperature and acid appears to be so harsh that above 60°C *Sulfolobus* is the only form of life in solfatara soils and waters.

From early laboratory studies, we learned that *Sulfolobus* can obtain all its energy by oxidizing elemental sulfur to sulfuric acid. Since sulfuric acid is one of the main features of *Sulfolobus*'s surroundings, we wondered about the bacteria's role in creating and maintaining their habitat, that is, in producing sulfuric acid on a geologically significant scale.

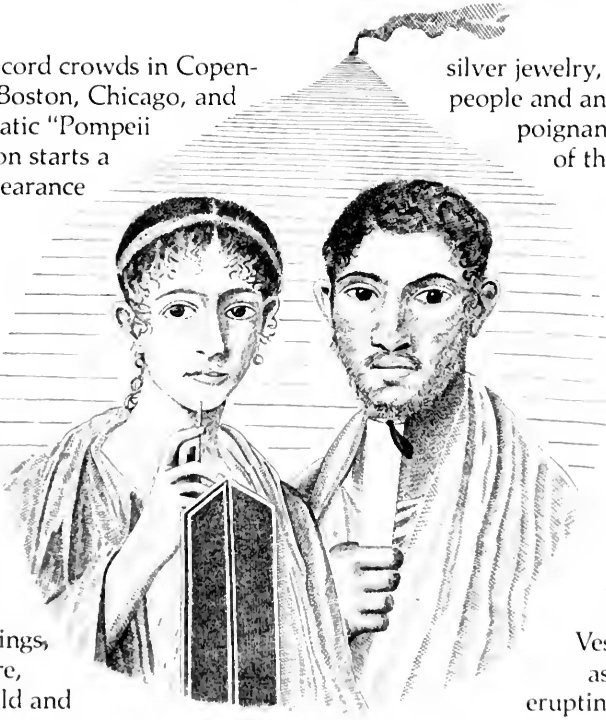
We found we could measure the rate at which the bacteria oxidized sulfur to sulfuric acid by placing samples of *Sulfolobus*-containing spring water in bottles, adding radioactive sulfur crystals, incubating the bottles in water baths at hot spring temperatures, and measuring the rates of sulfur oxidation in the bottles. In doing this, we left the bacteria in their natural environment, yet obtained experimentally manageable samples. Bottles could also be incubated at various temperatures to determine the temperature at which the bacteria function best.

We learned two things from these experiments. *Sulfolobus* does oxidize large amounts of sulfur to sulfuric acid. And it prefers high temperatures. Many populations are most active metabolically at 80°C. Only in the hottest locations, 90°C and above, do the bacteria appear to be under stress.

One striking feature of many of the springs inhabited by *Sulfolobus* is their constancy. Returning to them many times over the course of several years, we found only infrequent and usually minor changes. In general, the amount of water and its temperature, the number of bacteria, and the concentrations of chemicals in the water—hydrogen sulfide, sulfur, and sulfuric acid, for example—remain constant. Actually, acid springs are more like

POMPEII (AD 79) IS COMING TO NEW YORK!

APRIL 22 - JULY 31 A D 1979 AT THE AMERICAN MUSEUM OF NATURAL HISTORY



After drawing record crowds in Copenhagen, London, Boston, Chicago, and Dallas, the dramatic "Pompeii AD 79" exhibition starts a three-month appearance at the American Museum of Natural History in April—the final showing before it returns to its permanent location at Italy's National Archaeological Institute.

Over 300 art objects and artifacts—wall paintings, mosaics, sculpture, pottery, glass, gold and silver jewelry, and plaster casts of people and animals—vividly and poignantly recapture the life of the ancient city at the moment Vesuvius erupted on August 24th, A.D. 79.

Concurrently, "Volcano!" an exhibition prepared by the Museum's Department of Mineral Sciences will be shown. It contains volcanic materials, including lava and ash from Vesuvius itself, as well as films of volcanoes erupting.

The exhibition has been arranged through the cooperation of the Italian Ministry of Culture, and is supported in part through grants from the National Endowment for the Humanities and Xerox Corporation.

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pools than springs; only rarely is there more than a trickle of water from them. Superficially, they appear static, and this presented a dilemma. If *Sulfolobus* is actively producing sulfuric acid, how can the acid concentration in a spring remain constant? Similarly, how can the cell concentrations remain constant if the bacteria are reproducing, which we inferred from their metabolic activity?

It occurred to us that the springs were not static but rather dynamic steady-state systems. Perhaps water and nutrients enter the springs, the bacteria metabolize the nutrients and reproduce, and water containing bacteria and metabolic wastes flows out—all at the same constant rate. Presumably, such a flow would be by subsurface seepage since there is negligible visible flow into or out of most of the springs. Bacteria normally go through a cycle of growth to a maximum cell concentration and then begin to die. In the laboratory, microbiologists frequently contrive an apparatus—called a chemostat —that, by continuous dilution, maintains bacteria in a steady state of growth. Had we found a kind of natural chemostat?

If there was continuous exchange, or turnover, of the pool contents, we should be able to detect it by adding a marker—a soluble chemical, for example—to the water and determining what happened to it. If a marker that neither evaporated nor decomposed in the water nevertheless disappeared, we would know that a turnover of water contents did occur. And we could at the same time measure the rate of the marker's disappearance, or the spring's turnover time.

We chose common table salt as a marker because it is inexpensive, soluble in water, and stable. And we already knew that it did not harm the bacteria at the low concentrations needed. Moreover, since it is a relatively innocuous natural substance, it should have no effect as it is diluted into the environment from a spring.

We added salt to several *Sulfolobus*-containing springs and found that it did disappear and in a significant way: as an exponential function of time. This is merely a fancy mathematical way of saying that the salt disappeared just as if it had been added to a continuously and thoroughly stirred container with water flowing into and out of it at a constant rate. And at the same time that this was happening, the springs appeared to be unchanged—temperature, cell concentrations, and sulfuric acid concentrations remained constant, as always. In other words, the springs behaved just like chemostats.

This observation permitted us to draw conclusions about how fast *Sulfolobus* grows and produces acid in nature. If bacteria and sulfuric acid are flowing out of a spring at a particular rate, to maintain the steady state they must be replaced at the same rate, either by growth and metabolism within the spring or by being carried in by the incoming water.

It turned out that the bacteria do not flow into the springs with the ground water, but grow right in the pools. We learned this by draining some *Sulfolobus*-containing springs, siphoning their contents downslope with a length of hose. At the bottom of the pools, steam vents heated the ground water that continued to seep into the pools. The pools filled in a few hours. The first water to reenter had no *Sulfolobus* cells, but the few bacteria apparently remaining in the emptied springs reproduced rapidly to return the populations to their original numbers.

Most of the springs turn over their water supply in about one day, so the bacteria must also reproduce at this rate to maintain their constant cell concentrations. Two unusually large pools, however, turned over much more slowly. In these, the bacteria have to double their numbers only every thirty days to maintain themselves, but it is likely that a cyclic process of division, death, and disintegration permits growth rates faster than those required to maintain the steady state.

Even though *Sulfolobus* maintains its populations by growing right in the springs, the proportion of sulfuric acid actually produced in a spring is determined by the spring's size. Large springs have a low turnover rate, since water entering them is mixed into a large volume and so makes up a small fraction of the total volume. In very large springs, essentially all the acid is produced right there. Small springs, on the other hand, have

very fast turnover rates. In fact, water flows through them so fast that, even though the bacteria maintain themselves by reproduction right in the spring, most of the acid leaving a spring is already in the water that seeps into it, having been produced somewhere upslope —in another spring or in the soil— as the ground water moves through the thermal area.

Sulfolobus also lives in the soil around hot springs. And in the cooler portions of solfataras—below 50°C—other, more common sulfur-oxidizing soil bacteria are found. Together, these soil-dwelling bacteria probably account for much of the acid passing through small springs.

Sulfolobus intrigues both microbiologists and geochemists because it is a living geochemical agent, active in forming and maintaining acid thermal areas. Its unique relationship to its environment permitted us to deduce much about its ecology. Bacteria cannot usually be studied so easily in nature.

Geothermal areas have probably existed since shortly after the earth's formation and may have been more widespread on the primitive earth. We, and others, have wondered whether high temperature bacteria living today are relicts of ancient forms of life. There is now evidence that some of them are. Geneticist Carl Woese and his associates at the University of Illinois recently concluded that two of our new high temperature bacteria belong to an assemblage of organisms they call archaebacteria, or ancient bacteria, because their genetic code is so different from that of other bacteria that they must have been evolving as a distinct group for several billion years.

Methane-forming bacteria, which require oxygen-free, or anaerobic, habitats and consume hydrogen and carbon dioxide, were first recognized as members of this group. And now other bacteria—all living in extreme environments—are known to belong to the group too. They include the halobacteria, which require high salt concentrations, such as those found in Great Salt Lake, to survive, and our new hot acid bacteria, *Sulfolobus* and *Thermoplasma*. *Thermus*, however, seems to have adapted to life at high temperatures much more recently since it is genetically dis-

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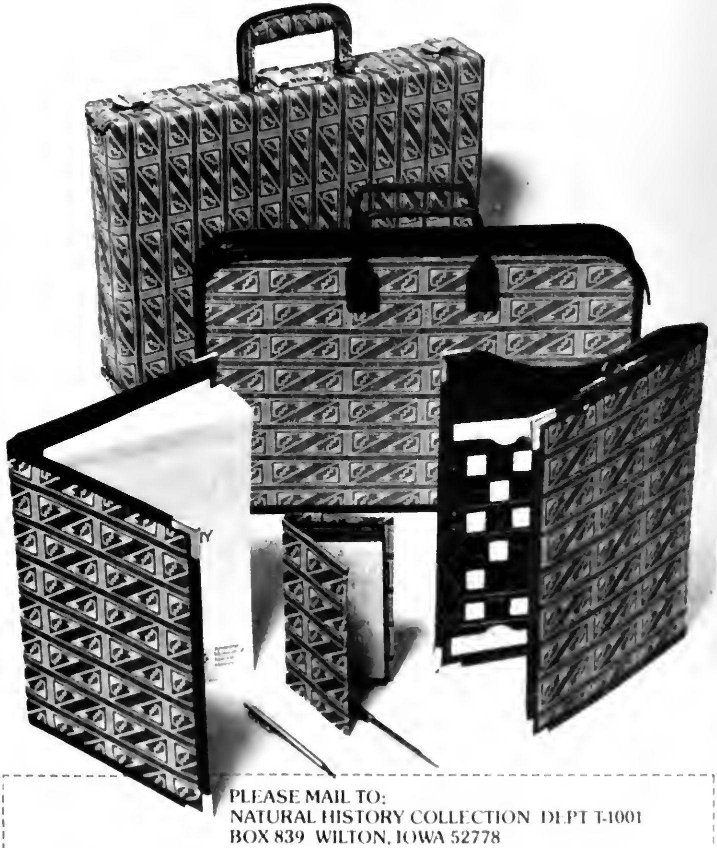

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tinct from *Sulfolobus* and *Thermoplasma* and resembles other, more normal bacteria. The archaebacteria may date back to the primitive earth, when conditions more appropriate to their adaptations prevailed.

Descendants of bacteria present on the primitive earth would be expected to evolve into quite different types in isolated locations. Yet, clearly recognizable *Sulfolobus* cells are found not only in the hot springs of Yellowstone National Park but also in solfataras in Italy, Dominica, El Salvador, and New Zealand. In fact, *Sulfolobus* cells in one spring in Yellowstone are so closely related to a *Sulfolobus* in a New Zealand spring that the immune system of rabbits—commonly called upon by microbiologists to distinguish between similar bacteria—cannot tell them apart. Some mechanism of global distribution, most likely by air or water, must exist. But since dormant cell structures that could survive desiccation and low temperatures have never been seen, we cannot guess what it might be.

All the bacteria we have described *require* high temperatures; they cannot survive at temperatures considered normal for life. They are truly thermophilic and not simply tolerant of high temperatures. The normal human body temperature of 37°C, for example, is much too low for these bacteria.

Most proteins lose their structures in boiling water, and many biological molecules are broken down by hot sulfuric acid. Obviously, the high temperature bacteria have overcome these limitations. What special properties permit them to flourish where others cannot survive? Biochemists are only beginning to study these new organisms to learn what chemical modifications enable them to survive their harsh treatments, so the question cannot be fully answered yet.

We would guess that only surface structures of the acid-dwelling organisms are exposed to acid since other bacteria are known to exclude acid from inside their cells. And it is known that *Sulfolobus* and *Thermoplasma* contain acid-resistant bonds in their surface membranes in place of the usual acid-sensitive bonds.

But all cellular components must

withstand the high temperatures since cells cannot operate air-conditioning systems. We know, for example, that one enzyme isolated from *Thermus* is most active at 90°C (hotter even than the optimum for growth, 70° to 75°C) and is stable to heat inactivation up to about 100°C. Such modifications are of fundamental scientific interest and may eventually find practical application as well. Heat-stable cellular components should be useful in biological research. And heat-stable enzymes, the chemical catalysts of the cells, are already finding use in industrial processes.

We believe these high temperature bacteria live near the extremes of habitability, but we do not know the limits of life. No one knows, for example, the maximum temperature for life. There seems to be no reason why bacteria cannot live at temperatures higher than those in hot springs, as long as liquid water is present. However, there may be upper temperature limits for certain forms of life. Blue-green algae and photosynthetic bacteria seem to have a limit of 70° to 75°C. Eucaryotic microbes, which are a step above bacteria in cellular complexity because they have membrane-bound nuclei, are restricted to temperatures lower than 60°C, and animals are limited to less than 50°C. If thermophiles preferring yet higher temperatures are found, they will most likely be nonphotosynthetic bacteria.

In these days of space exploration it seems reasonable to ask whether the existence of high temperature microbes raises expectations of finding life on other planets. Of our nearest and most similar planetary neighbors, Mars is much colder than the earth and so not a place to look for thermophiles, while Venus, closer to the sun, may be too hot. Venus's surface reaches about 500°C. What is more, Venus seems to have no molecular oxygen, very little water, and showers of concentrated sulfuric acid are thought to occur. Hot springs and hot-water heaters are mild compared with this. Even *Sulfolobus* would find Venus inhospitable. And yet, the very existence of earthly organisms such as *Sulfolobus* suggests that we should reserve judgment about the possibility of life under such conditions. In truth, we do not know the limits of life. □

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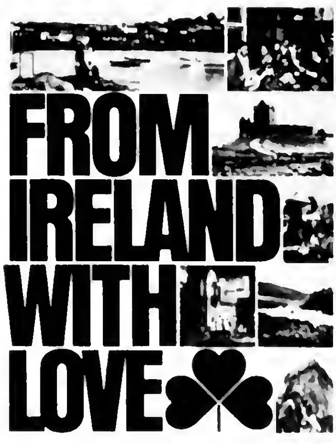

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A Basic Brew

Beer is a natural product dating back to ancient times

When I first moved to New York, to work as a summer intern at a news magazine, I sublet an apartment on the Upper East Side in a neighborhood that looked respectable. But on especially warm days, a noisome stench assaulted me as I strode out the door, my mind on "Career." There was, I soon found out, a major brewery down the street, spewing malty exhalations into the air.

It isn't there any more. The land was too valuable; the odors were too strong. But I am always wistful when I pass the site because the unignorable smell of brewing, which used to pour out of it, was my first introduction to the crazy, anarchic mix of elegance and grit that is Manhattan's essence. In Detroit, where I grew up, there was a vanishingly small amount of elegance and plenty of grit, but the workaday parts of life were rarely visible. The leading local brewery spent a fortune on ads that boasted about its "fire-brewing" process, which always reminded me of the aria from *Messiah*, "For He is like a refiner's fire." Fire brewing sounded so pure and antiseptic. It certainly did not occur to me then that beer was a natural product that had been made for eons, without benefit of fire brewing or any other sort of high technology. Even the smelly New York brewery was an urbanized, modern, and relatively faceless industrial descendant of the home brewing that was once so common on farms in many countries. George Eliot, always a mine of detail about rural and village life, shows this in *Adam Bede* with scenes of housewives passing out glasses of their latest batch of beer.

Beer is really a primitive human artifact. Some authorities trace it as far back as ancient Mesopotamia. Others speculate that it may have been the primordial form of grain exploitation. This is not as farfetched as it sounds because the original discovery of beer (no doubt many times and in many places) must have been an accidental result of primeval attempts to deal with recalcitrant barley kernels.

Barley (*Hordeum vulgare L.*) is the hardiest of all grains. Its cultivation began so long ago there is no tracing it to any local source, but the toughness of this cereal grass made it an appropriate crop for chillier climates, places where grapevines would not grow well; the same places where beer is still the typical beverage. The trouble was that the kernels were too hard to eat in their natural state. With the invention of mechanical milling, however, it became possible to grind barley into the small round grains that we call pearls and still eat in Scotch broth and other soups. Barley flour was also once a vital part of the northern European diet. Wheat bread in rural England and Wales was a fancy food; housewives usually stuck to cheaper oatmeal and barley breads.

Some people still hunt around for barley flour and compensate for its low gluten content (and the dense, heavy effect that it has on bread dough) by mixing it with wheat flour. Elizabeth David, in *English Bread and Yeast Cookery,* recommends approximately four parts wheat to one part barley flour (by weight). "Although," she concedes, "owing to its grayish crumb, barley bread may not look immediately appetizing, those who acquire a taste for it are likely to become addicts. I am one."

David does not mind that barley

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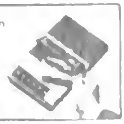

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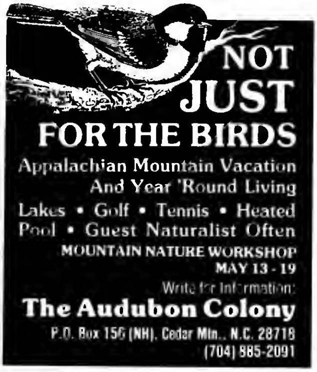

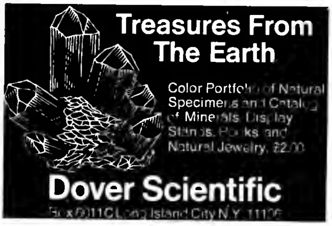

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bread goes stale quickly. She loves it on account of its "unmistakably earthy tang." Another barley bread enthusiast, quoted by David, was John Keats, who wrote, from Teignmouth in Devonshire:

> Here all the summer could I
> stay . . .
> Where, close by the stream,
> You may have your cream
> All spread upon barley bread.

British cooks in Wales, Scotland, and parts of northern England also used to make barley bannocks (flat, griddle-cooked breads) more commonly than oven-baked loaves. David reports, moreover, that barley flour was the basis of the crust of Christmas goose pies in Cumberland and that barley meal pancakes raised with yeast are still a special treat.

Such recommendations notwithstanding, barley baking is irrevocably a thing of the past, a quaint reminder of the way things were before cheap wheat swept the field of other grains. And yet, barley flour itself is an advanced product compared with the malt barley from which we still make beer.

Malt is, quite simply, barley that has been steeped in water until it germinates. Professional maltsters take great care to turn the shallow heaps, or couches, of grain until sprouts begin to grow inside the kernel. They spread the sprouted grain out to control growth, and after several days the "green" malt is dried and stabilized.

The basic simplicity of the process made it an attractive method for farmers before milling was known or when access to a mill was impractical. Malting softened the grain and made it edible. It also improved the flavor and made the starches in the grain soluble, made them, that is, accessible to yeast.

This last feature of the malting process must at first have been a decided disadvantage. It exposed the grain to infections from all manner of molds and spoilage. But on one fateful day (undoubtedly, on many such days in many places), yeast invaded somebody's malt and made him an inadvertent brewer.

Beer, at its most basic, is malt fermented with yeast. The fermentation, when managed in modern breweries, yields a dark, carbonated liquid containing, typically, about 5 percent alcohol. This brew is dense, rich, and alive. Drunk as is, however, it tastes thick and sticky. The Elizabethans would have called it ale. True beer in those days was further refined and stabilized and flavored with hops, *Humulus lupulus* (a plant known to the ancients but apparently not much used in beer). Other plants, mainly those with essential oils, such as juniper, coriander, and bay leaves, served the same purpose. But the cone-shaped flower, or strobile, of the hop turned out to be an ideal source of resins, oils, and tannin.

After hops were added to the malt mash, known as wort, the mixture was boiled—this was the actual brewing stage. The hops were then removed and yeast put in. In this process, the yeast floated to the top of the fermentation vessel. Beer still made in this way, by top fermentation, is what we now call ale in this country. Until the early fifteenth century, all beer was top fermented. But about 1420, in Bavaria, it was discovered that if fermenting beer was packed in ice, the yeast would settle to the bottom and the end product would turn out much clearer. Bottom fermentation, however, did not come into its own, except in mountain areas with plentiful supplies of natural ice, until the nineteenth century, when artificial refrigeration permitted brewers everywhere to switch over to this refinement.

Since then, brewing has evolved ever further from the old style of farmhouse production. Pasteurization and other "advanced" techniques and stabilizing additives take the edge and flavor off almost all mass-produced beers, removing it from its origins and thereby reducing its personality. The merger and consolidation of local commercial breweries has also squeezed individuality out of the beer most Americans can find in their markets and liquor stores.

The ideal beer-drinking situation—abundant, unpasteurized, hand-tailored-beer—exists almost nowhere in this country. For the old-fashioned beer, one almost has to go abroad to Germany or Czechoslovakia. In Great Britain there is an admirable movement to preserve "real" beer and ale. But I think that Belgium is the true capital of the beer world. In the district known as Payottenland, on the river Senne

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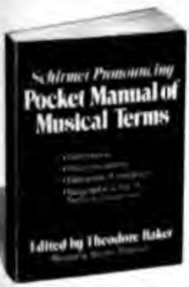

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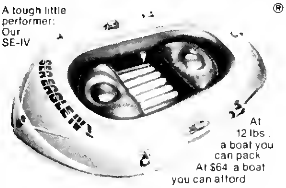
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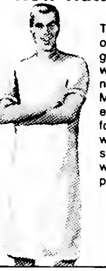
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west of Brussels, some very old-fashioned breweries still make so-called wild beers—beers with wheat in the mash—that ferment spontaneously without the addition of yeast. Some Belgian beers are matured for years. There is even a variety, called *kriekenlambic*, that contains black cherries. The list could be extended since, for example, Trappist monks in Belgium brew their own distinct variety of strong beer, and other Belgian brewers make a highly alcoholic "Scotch" ale for Christmastime.

With such a profusion of beer styles, it stands to reason that Belgians should have learned to cook with their national beverage just as the French and Italians focused on wine in their kitchens. A legendary Belgian cookbook (I have been unable to locate a copy) contains more than 300 beer-based recipes. Nika Hazelton in her splendid *The Belgian Cookbook* discusses a recipe for beer and turkey stew from this stupendous Belgian collection (its title, *La cuisine au pays de Gambrinus*, commemorates a thirteenth-century Belgian duke, Jan Primus, whose name was corrupted into Gambrinus or Cambrinus when he became known throughout Europe as the king of beer because of his feats as a toper). Oddly, Hazelton never actually made the dish. The version below is an attempt at a workable recipe. Whether it is absolutely authentic is unclear, but this stew, as printed here, has the earthy force of its cousin, carbonnades flamandes.

The obvious garnish to go with it—hop sprouts—may be a little hard to find in most markets. But what a fine thing it would be, given the chance, to boil them, in the folkloric Belgian manner. Hops must be picked in May, when they are tender. Then, cook them like asparagus, in lightly salted water to cover, water that has been acidulated with the juice of one lemon. Simmer briefly until tender, drain, and serve with heavy cream heated with a bit of butter. For extra richness, put a few poached eggs on top. Pour yourself a glass of beer and drink a toast to Gambrinus or to John Barleycorn.

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

Salmis of Turkey Frans Hals

1 very small, 5–6 pound turkey or the equivalent in frozen turkey parts
Giblets from two chickens, optional
A few chopped-up veal bones
1 quart dark beer
1 quart beef or chicken stock
Salt
Paprika
Flour for dredging
4 tablespoons butter
½ pound mushroom caps
1 egg yolk beaten into ¼ cup heavy cream
½ cup Holland gin

1. Cut the turkey into 8 pieces. Remove and discard skin. Reserve turkey pieces.
2. To make a stock, combine the turkey neck and gizzard (or the optional chicken giblets), the veal bones, the beef or chicken stock, and the beer in a large pot.
3. Bring stock to a boil, skim, reduce heat, and simmer, covered, for an hour. Strain the stock, discard solid ingredients, and skim off the fat from the liquid.
4. Return the defatted stock to the heat, bring to a full boil, and reduce to 3 cups.
5. While the stock is reducing, rub the turkey pieces with salt and paprika and dredge them in flour.
6. Heat half the butter in a skillet until the foam subsides. Sauté the turkey pieces a few at a time, until they are golden on all sides. Drain and set aside until all the turkey is sautéed.
7. Put the browned turkey and the reduced stock into a large casserole. Simmer, covered, until the pieces are about three-quarters done, about 1 to 1½ hours depending on the size and age of the bird. Remove the meat and set aside.
8. Sauté the mushroom caps in the remaining butter and the Holland gin.
9. Stir the egg yolk–cream mixture into the stock. Continue stirring over low heat until the stock thickens. Then add the turkey, mushrooms, and gin. Finish cooking, covered, over low heat, for another 30 minutes.

Yield: Six servings

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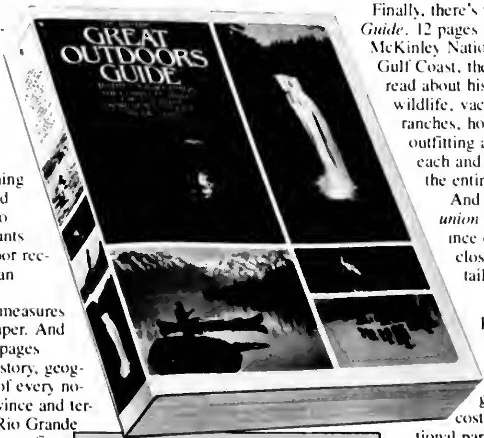

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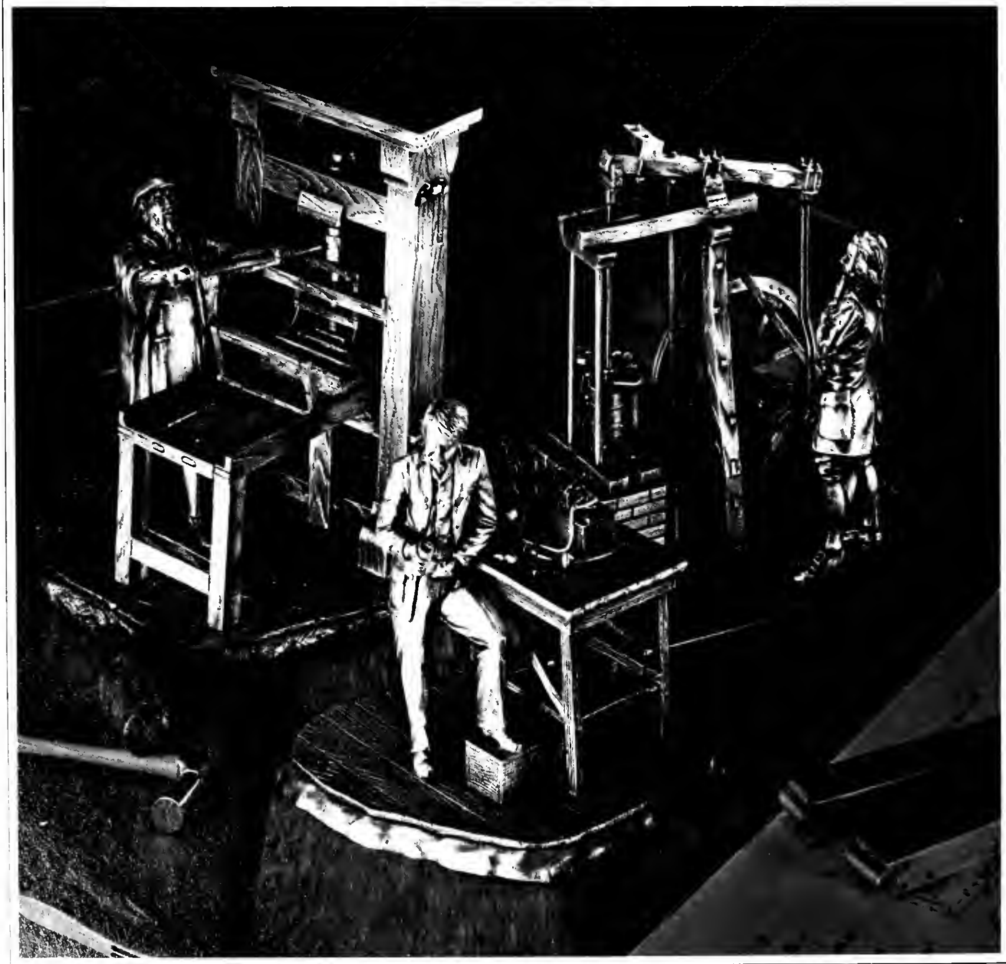

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Toward a Concept of Man

ON HUMAN NATURE, by Edward O. Wilson. *Harvard University Press, $12.50; 260 pp.*

E. O. Wilson is a Harvard entomologist, a zoologist who has written elegantly and prolifically on behavior and ecology, and a man at the center of one of science's most stimulating and provocative controversies, sociobiology. Sociobiology attempts to derive general principles concerning the behavioral properties of populations. This is Wilson's third volume in a sequence that has moved from insects to vertebrates to humans. As the argument has moved closer to humans it has become, as one might expect, more heated. Wilson's aim is not modest: to derive a view of human nature that integrates the social sciences, especially anthropology, with the natural sciences, particularly neurobiology and ethology. His ambitious intention is to specify which human behaviors are subject to genetic control, and to what extent, so that we can make conscious choices about the future of society. "We can hope to decide more judiciously which of the elements of human nature to cultivate and which to subvert, which to take open pleasure with and which to handle with care." Finally, he suggests that current secular and religious ideologies will eventually be replaced by "the evolutionary epic," the "best myth we will ever have."

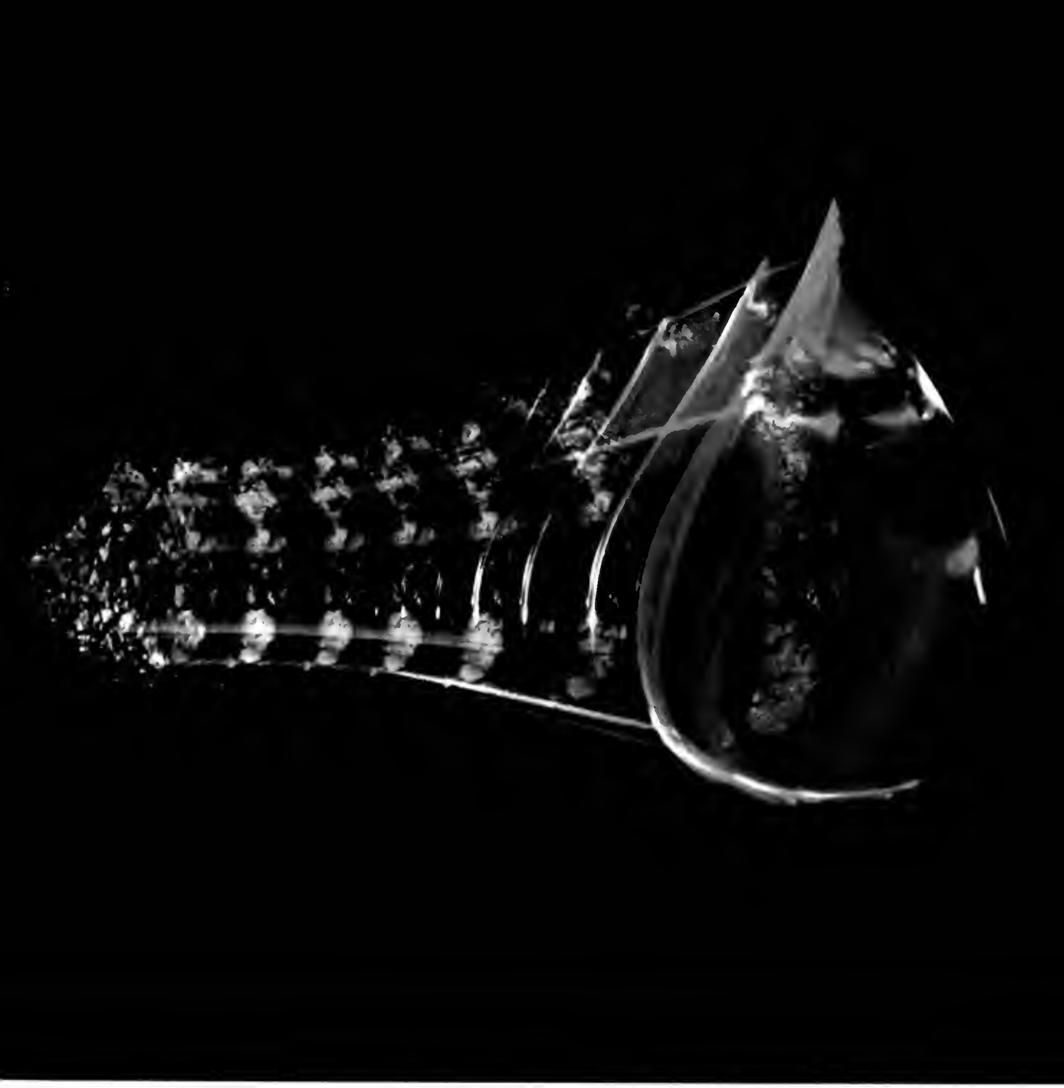
Wilson's book is eclectic, surveying a literature of considerable breadth that spans the humanities, social sciences, and natural sciences. It aims to be both an explanatory analysis of a body of data and a freewheeling speculative attempt to spell out the ethical and biological consequences of this particular synthesis.

The first four chapters lay out the arguments, which can be briefly summarized as follows. Much more of human behavior than is normally admitted by humanists and social scientists reflects predispositions that are under genetic control. Virtually all behavioral traits are functions of both genes and environment, evolving and developing as complex interactions of the two. Most major human behavioral patterns are developmentally constrained; consequently, they are very easy to learn and difficult to suppress. The human behavioral repertoire evolved over the last several million years, during most of which humans were Ice Age hunter-gatherers. Many of the behavioral patterns we now display were once adaptive in our hunter-gatherer past. However, much modern human behavior is a product of relatively recent and rapid cultural evolution, overlaying, but never obscuring, those patterns that were evolved earlier.

All human cultures exhibit certain behavioral traits: these "universal" characters are innate and easily learned and have evolved as part of the human species' repertoire. Among them are incest taboos, sex role differences, religious behaviors, and so forth. Wilson explores four important behavioral categories in depth: aggression, sex, altruism, and religion. In the first case, he argues that aggressive behavior in humans is easily learned and hard to suppress; therefore, ultimately innate. We can "only work our way around" our aggression, although "undoubtedly there exist . . . techniques by which this aspect of human nature can be gently hobbled in the interest of human welfare." Similarly with sex differences: females are less assertive and aggressive, more nurturant than males because of the evolution of genetic predispositions important in our hunter-gatherer pasts. However, these physical and temperamental differences become culturally hypertrophied in most human societies. It would be possible to "override" biology and sanction an egalitarian society, but this would have costs and require careful consideration. "One way or other, intuitively or with the aid of science, evolutionary history will be entered in the calculations, because human nature is stubborn and cannot be forced without a cost."

It is the same with altruism: self-sacrifice in humans has a genetic basis. Wilson distinguishes two kinds of altruism. In the "hard-core" type, an individual's sacrifice may enhance survival of relatives carrying some of the same genes. "Soft-core" altruism is ultimately more selfish because it is calculating—individuals act altruistically in exchange for future favors (including those in the hereafter in the case of saints). Thus does sociobiology have something to say about ethics and how ethical behavior is constrained. This leads ultimately to religions, both sacred and secular (i.e., Marxism). Again, a quotation summarizes most efficiently: "Incest taboos, taboos in general, xenophobia, the dichotomization of objects into the sacred and the profane, hierarchical dominance systems, intense attention toward leaders, charisma, trophyism, and trance-induction are among the elements of religious behavior most likely to be shaped by developmental programs and learning rites. . . . Such constraints exist . . . they have a physiological basis, and . . . the physiological basis in turn has a genetic origin. . . . [Thus] ecclesiastical choices are influenced by the chain of events that lead from the genes through physiology to constrained learning during single lifetimes."

Ultimately though, positivist science will undermine the basis of religious beliefs and eventually replace other ideologies to become *the* final religion. Although our behaviors are innately determined, we can to some extent make conscious choices among them. Science will



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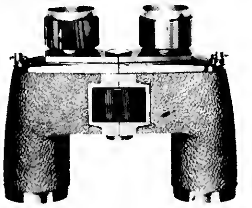

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provide the means of understanding and dominating nature, serve as the mythology to satisfy our deepest biological urges, and keep alive the possibility of a rationally planned and better future.

So much for an admittedly brief and selective account of the sociobiology of human nature. Sociobiology has been controversial, especially during the past three years, and the debate has often been bitter, as might be expected since such important issues are involved. Critics have ranged from biologists dissatisfied with the genetic or behavioral parts of the theory, to social scientists committed to the view that in its richness and complexity human behavior is vastly different from that of nonhumans, so much so that it cannot be mechanistically reduced to a few innately patterned processes. Others have argued that sociobiology is inherently objectionable since it is deterministic and, consequently, can be used to support sexist, racist, and naturally hierarchic views of human behavior and society.

The idea that much of human behavior is "natural" in the sense of being inherited, evolved, or otherwise genetically determined or constrained is not new. Almost all of us have opinions on the subject of human nature, which is hardly surprising since we are all in some sense experts. Darwin was a sociobiologist, the intellectual ancestor of many scientific (as opposed to lay) sociobiologists since then. The fuss over this particular deterministic theory seems to be a bit more intense this time, perhaps because many biologists and social scientists have become convinced protagonists of sociobiology. Sociobiology is based on a (relatively) elaborate theoretical foundation and has spread rapidly among certain scientists possibly because of its apparently rigorous formalism; perhaps, too, it satisfies some as yet unspecified, deeper need for order and explanation.

At the same time opponents have been a great deal more vocal in attacking both the "scientific" bases and the ideological implications of sociobiology, particularly where it can be said to justify an inequitable status quo. However, it is worth noting that there have already been feminist sociobiological attempts at explaining human evolution, with different conclusions from Wilson's. Not all sociobiology leads inevitably to a particular kind of sexism or racism.

I am a paleoanthropologist, interested in reconstructing human evolution, so I too am concerned with many of these same issues. I have little quarrel with Wilson's aims: humans have evolved, their behavior does have genetic as well as nongenetic components, and there may well be some practical application of knowledge about possible constraints on human behavior. We do indeed need a new synthesis, in fact, a whole series of syntheses that link genetics, neurosciences, behavioral sciences, cultural anthropology, and sociology, for which we probably will need a new breed of scientist that can transcend the "two cultures." But I believe Wilson's attempt to be flawed: the consummation, however devoutly wished, is incomplete.

I have many criticisms, but a few stand out as being particularly important. First, there are problems with the use of language. The work is full of metaphors derived from economics, game theory, systems analysis—"deep" and "hard" permeate the work. Dichotomies abound. Nature and nurture, innate and learned, biology and culture, limbic system and cortex are constantly juxtaposed. Both the metaphors and the use of dichotomies lead to serious errors. Wilson sees humans as evolving from a biological to a cultural state, the shift in behavior reflecting brain evolution. The brain is viewed stratigraphically, with the younger, newer cortex responsible for our learned cultural behavior overlying the archaic, "deep" limbic system that is the seat of emotions. We cannot ignore emotions: they are linked closely to genes, and prevent behaviors straying too far—"genes hold culture on a leash."

It would take a linguistic philosopher to do justice to this book, but I believe Wilson is playing tricks with words. For example, human behavior cannot be separated into "biological" and "cultural" components. Culture is part of our biology or rather an ability to use symbols is integral to our behavioral repertoire. As many social anthropologists have argued, a "culture-

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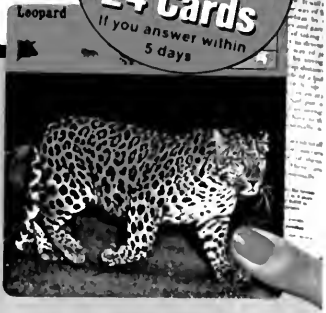

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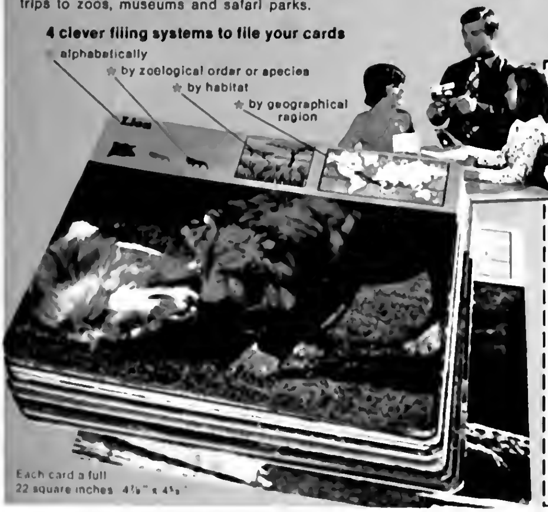

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A second, linked problem revolves around Wilson's relative ignorance of social anthropology and the concept of culture. The task of coming to grips with the bewilderingly complicated array of human behaviors is daunting even to professional anthropologists. It is not easy to make generalizations about humans; an inability to do so, or to produce anything other than quite trivial statements, is not a sign of willful avoidance or of incompetence. It is just incredibly hard to do. Culture is also a difficult concept. Wilson uses the term in at least four different ways, still a small subset of all possible meanings, and in the end fails to come to grips with the ways in which learned behavior in humans differs from that in nonhumans.

If a science of human behavior is to be successful, it will have to be able to fully comprehend and describe interactions within and between many organizational levels, from the molecular to the complex behavioral. Wilson attempts to connect what is currently known from molecular, developmental, and behavioral genetics, neurophysiology, neuropharmacology, experimental and social psychology, sociology, and social anthropology. It should hardly be a surprise that he fails in such an ambitious task, both because we do not yet know nearly enough about the behavior of any of these complex systems and because essential analytical ingredients, such as the culture concept, are omitted.

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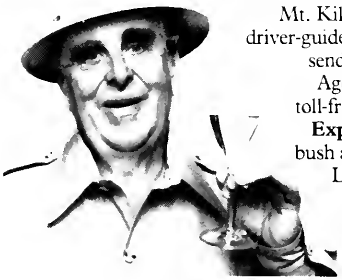

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good case in point. This is a complex and difficult issue that needs much more work. The other topics surveyed by Wilson are even further from solution. I found the leap from neurons and hormones to religion and reciprocity particularly hard to follow—or swallow. An additional problem intrudes here, that of classification. Are all behaviors labeled "religious" or "ecclesiastical" comparable? Do they all have the same motivations, genetic mechanisms, or outcomes? In what analytically useful sense is the concept "Marxism" equivalent to "Shintoism." Placing many different, highly complex behaviors in the same category ignores critically important diversity.

Central to sociobiology is the ability to recognize adaptive behaviors. Unfortunately, many behavior patterns can be classified in ways that make them appear universal, and adaptive explanations are then not hard to find. One major problem here concerns the ease with which humans perceive patterns in nature and are able to come up with explanations for them. Explanation is facilitated by the conjunction of the powerful, yet simple, theory of sociobiology with richly complex data from behavior studies. Recently, infanticide among Indian monkeys was given an elegant sociobiological "explanation" in terms of male and female "strategies" and "investments." Subsequently, what was to me a more plausible alternative explanation was proposed: infanticide was an aberrant response of some monkey populations to ecological disturbance. With human behavior the game is still easier to play: classifications can be adjusted to find universals, which can always be interpreted in some way as adaptive. The problem lies in evaluating the explanations.

Many sociobiological analyses of human behavior claim support from studies of primate behavior and human evolution. I am not qualified to judge the contribution of primatology, although different lessons can clearly be learned from the same monkey or ape depending on the implicit assumptions of different students. For paleoanthropology I feel on firmer ground: it has been misused. For example, sociobiology is often used to argue that sex differences in behavior

have their roots in the evolution of hunting-gathering. Similar "principles" are used to justify the claim that religious beliefs were of pronounced survival value for Paleolithic man. However, as with studies of nonhuman primates, stories of human evolution often do little more than subtly underline and reinforce what seems to a particular author to be natural in living humans. Unfortunately, behavior does not fossilize, which makes possible a fairly wide range of interpretations, many quite plausible. Often what has been said about the past has been a reflection of the present, just as we have seen in primates simpler versions of what is natural in us. I fear that we cannot expect studies of the past to help us much with the evolution of those complex human behaviors that fascinate us, any more than we can use our noncultural primate cousins to tell us about religious beliefs or mob violence or potlatch ceremonies.

I do not object to Wilson's goals: they are laudable, and I hope he and many others will continue to strive for fuller syntheses. But we are going to need much more culturally sophisticated analyses and much less simple explanatory schemes. I have at the moment no "big picture" to put in the place of this human sociobiology. I have no feel for what is quintessentially human, except perhaps the ease with which we learn to be different from each other. Maybe "culturation" is the key, our species' alternative to speciation as a response to habitat diversity. In that case, as C. Geertz has argued (*The Interpretation of Cultures*), "It may be in the cultural particularities of people —in their oddities—that some of the most instructive revelations of what is to be generically human are to be found; and the main contribution of the science of anthropology to the construction—or reconstruction—of a concept of man may then lie in showing us how to find them."

David Pilbeam is professor of anthropology and of geology and geophysics at Yale University. His research includes the study of the interface between the historical and scientific aspects of paleoanthropology, in particular the role of implicit assumptions in thinking about human evolution.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon During February, the sun recovers from its midwinter reclusiveness. In the sky for only about 10 hours on February 1, it climbs barely one-third of the way up the sky at noon. But by March 1, the day will be nearly 11½ hours long, and the noonday sun will move up almost halfway to the zenith. On February 1, the sun is in the constellation Capricornus; it will move into Aquarius by the 16th, and into Pisces before mid-March.

The moon is an early crescent on February 1, becomes first-quarter on the 3rd, and full on the 11th. Waning thereafter, and rising later, it reaches last-quarter on February 19 and will be new on the 26th, when it will eclipse the sun (see p. 24). In March, first-quarter is on the 5th and full moon on the 13th.

Stars and Planets The winter constellations dominate the southern sky early on February evenings, with Orion at its highest, more than halfway up from the horizon. The two brightest objects to its left (except when the moon is there) are the star Sirius and the planet Jupiter; the planet is the brighter and the higher of the two, located below the twin stars Pollux and Castor. To the left and below Jupiter, you can see the star Regulus and the planet Saturn rising in the early evening; Saturn is the lower and brighter of the two. The moon moves through the winter star group in early February (and again in March). It passes Aldebaran (in Taurus) on the evening of February 5, will be above Orion on the 6th and 7th, between Procyon (below) and Castor and Pollux (above) on the 8th and 9th, below Jupiter on the 10th, below Regulus on the 12th, and below Saturn on the 13th.

Jupiter and Saturn remain in the sky past midnight. Before dawn, they are joined by Venus, rising brilliantly as a morning star. By daybreak, Venus is low in the east and Jupiter low in the west. Saturn, above Jupiter and Regulus, is in the southeast. Mercury (an evening star) and Mars (a morning star) are poorly placed for viewing. Uranus, Neptune, and Pluto are also morning stars (visible at sunrise).

February 5–6: The star near the moon is Aldebaran. The moon passes in front of the star at about 7:00 P.M., EST, covering it for about an hour (an occultation).

February 9: Mercury enters the evening sky.

February 9–10: The bright object near the moon is Jupiter. The moon is at apogee (farthest from the earth) on the 10th.

February 13: The moon is near Saturn tonight.

February 23: Venus is below the moon this morning.

February 25–26: Perigee moon (nearest the earth) occurs only twenty hours before new moon and will strengthen the normally higher spring tides on the 26th and 27th.

March 1: Saturn is at opposition. Since it is now above the horizon at sunset, it is an evening star.

March 4–5: Another occultation of Aldebaran by the moon occurs tonight shortly after midnight, EST.

March 7: Mercury is at greatest distance (elongation) to the sun's left, placing it favorably for viewing as an evening star. From the 1st to about the 13th, look for it close to the horizon in the sunset glow during late twilight.

March 8–13: The moon will be a busy object. It is near Jupiter on the night of the 8th, reaches apogee on the 10th, passes close to Saturn on the 12th, and goes through the earth's shadow (a partial lunar eclipse, not visible in North America) on the 13th.

★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:10 P.M. on February 1; 10:15 P.M. on February 15; 9:25 P.M. on February 28; and 8:25 P.M. on March 15; but it can also be used for an hour before and after those times.

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Additional Reading

Manatees (p. 44)

In an effort to make people aware of the manatee's need for protection, the state of Florida has instituted a manatee-awareness program. For free fact sheets, brochures, and a bumper sticker, write to Manatee Information, State of Florida Department of Natural Resources, Crown Building, 202 Blount Street, Tallahassee, Florida 32304. There are few articles on the manatee currently available, but in late spring of 1979 the results of an intensive three-day workshop on the biology of the West Indian manatee will be published. The Public Affairs Office, Region 4, U.S. Fish and Wildlife Service, P.O. Box 95067, Atlanta, Georgia 30347, will have more information about this publication later in the year. "Florida's Manatees: Mermaids in Peril," a short, illustrated article by Daniel S. Hartman, which appeared in the March 1969 issue of *National Geographic* (pp. 342–53), is part of Hartman's eighteen-month study of the Crystal River manatees. Habitat, physiology, and behavior are discussed in "The Status of the Manatee in the Everglades National Park, with Notes on Its Natural History," by Joseph Curtis Moore (*Journal of Mammalogy*, February 1951, pp. 22–36). "Endangered Species: The Manatee," by H. W. Campbell and J. A. Powell, was the cover story of the April 1976 issue of *The Florida Naturalist*, a publication of the Florida Audubon Society. The article discusses the destruction of manatees by boats; it also includes an aerial photograph of 141 manatees—one of the largest aggregations on record—concentrated around the warm effluent of a power plant in winter. John E. Reynolds has published two other popular articles: "The Florida Manatee: Myth versus Truth" (*Sea Frontiers*, vol. 21, no. 6, pp. 209–14); and "Precarious Survival of the Florida Manatee" (*Oceans*, vol. 10, no. 5, pp. 50–53).

Seeds (p. 54)

Growth and dispersal trends of seeds are discussed in *The Population Biology of Plants*, by John Harper (New York: Academic Press, 1977). Søren Ødum's work *Dormant Seeds in Danish Ruderal Soils* has just been published by the Hørsholm Arboretum in Hørsholm, Denmark (1978). The article "Buried Viable Seed in Successional Field and Forest Stands, Howard Forest, Ma., 1968" can be found in the *Bulletin of the Torrey Botanical Club* (vol. 95, pp. 58–69). "The Role of Light in the Germination of Naturally Occurring Populations of Buried Weed Seeds," by G. Wesson and P. F. Wareing, was published in the *Journal of Experimental Botany* (vol. 20).

Gerbils (p. 64)

M. Daly and S. Daly have written extensively on the desert gerbil. Their articles, some of which are listed below, provide the data and scientific background for many points raised in "Of Libyan Jirds and Fat Sand Rats." "Behavior of *Psammomys obesus* (Rodentia: Gerbillinae) in the Algerian Sahara" (*Zeitschrifft für Tierpsychologie*, April 1975, pp. 298–321) is a detailed study of behavior, diet, communication, reproduction, sexual behavior, territory development, growth, dispersal of litters, and more. "Socioecology of Saharan Gerbils, Especially *Meriones libycus*" (*Mammalia*, vol. 39, no. 2, 1975), a report of a study on captive and free, marked animals, concludes that although gerbils are solitary, the habitats of different species overlap. Adult female gerbils occupy the best food sites and the spacing between these sites is nonrandom, according to "Spatial Distributions of a Leaf-eating Saharan Gerbil (*Psammomys obesus*) in Relation to Its Food" (*Mammalia*, vol. 38, no. 4, 1974, pp. 591–603). "On the Feeding Ecology of *Psammomys obesus* (Rodentia, Gerbillidae) in the Wadi Saoura, Algeria" (*Mammalia*, vol. 37, no. 4, 1973, pp. 545–61) contains more data on nutritional needs, and feeding rates and preferences of this gerbil. "Early Use of Solid Food by a Leaf-eating Gerbil (*Psammomys obesus*)" (*Journal of Mammalogy*, May 1975, pp. 509–11), by M. Daly alone, substantiates the claim that Saharan gerbils eat solid food at an earlier age than other gerbils. *Desert Animals*, by Knut Schmidt-Nielsen (Oxford: Oxford University Press, 1964), provides general desert biology with some information on gerbils for the layman. *Rodents in Desert Environments*, a collection of papers edited by I.S. Prakash and P. K. Ghosh (Dr. W. Junk B.V., Publishers, The Hague, 1975), is available in university libraries.

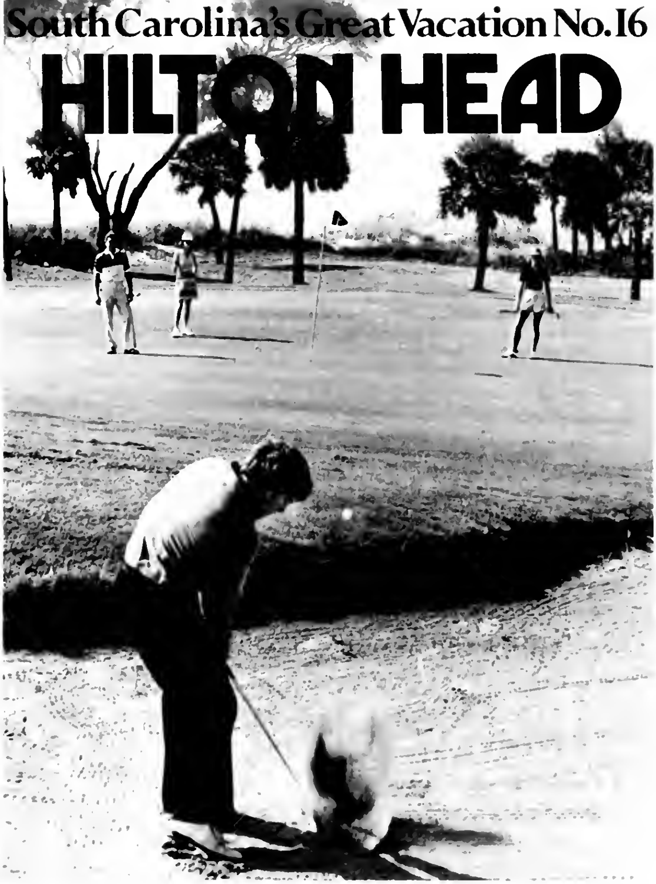
Ancient Diseases (p. 74)

Peru before the Incas, by Edward P. Lanning (Englewood Cliffs: Prentice-Hall, 1967), brings together archeological information from the late fifties and early sixties and discusses the growth of prehistoric Peruvian civilization. *The People of America*, by T. D. Stewart (New York: Charles Scribner's Sons, 1973), and J. Alden Mason's *The Ancient Civilizations of Peru* (Edinburgh: Penguin Books, 1957) are general books. One of Victor W. Von Hagen's

many books on ancient South American civilization is *Realm of the Incas*, available in paperback from New American Library. *Health and the Human Condition*, edited by Michael H. Logan and Edward E. Hunt (North Scituate: Duxbury Press, 1978), is a recently published collection of essays on medical anthropology. Its appendix lists review articles, abstracts and indexes, journals, bibliographies, and films on medical anthropology.

High Temperature Bacteria (p. 84)
Thermophilic Microorganisms and Life at High Temperatures (New York: Springer-Verlag, 1978), by T. D. Brock, covers ten years of the author's research in Yellowstone and other areas and provides hundreds of references. *Life in the Geyser Basins* (1971), a booklet by T. D. Brock and M. L. Brock, can be purchased from the publisher: Yellowstone Library and Museum Association, Yellowstone National Park, Wyoming. T. D. Brock and M. L. Brock published another article, "Life in a Hot-Water Basin," in the December 1968 issue of *Natural History* (pp. 46–53). The papers from a symposium held in Germany, edited by M. Shilo, will be published in the summer of 1979 in Berlin by Dahlem Konferenzen under the title *Strategy of Microbial Life in Extreme Environments*. Two articles of special interest to students of thermophilic microorganisms are "Life at High Temperatures," by T. D. Brock (*Science*, 158, 1967, pp. 1012–19); and "The Genus *Thermoplasma*," by R. T. Belly, B. B. Bohlool, and T. D. Brock (*Annals of the New York Academy of Sciences*, vol. 225, 1973, pp. 94–107).

Katharine D'Agosta



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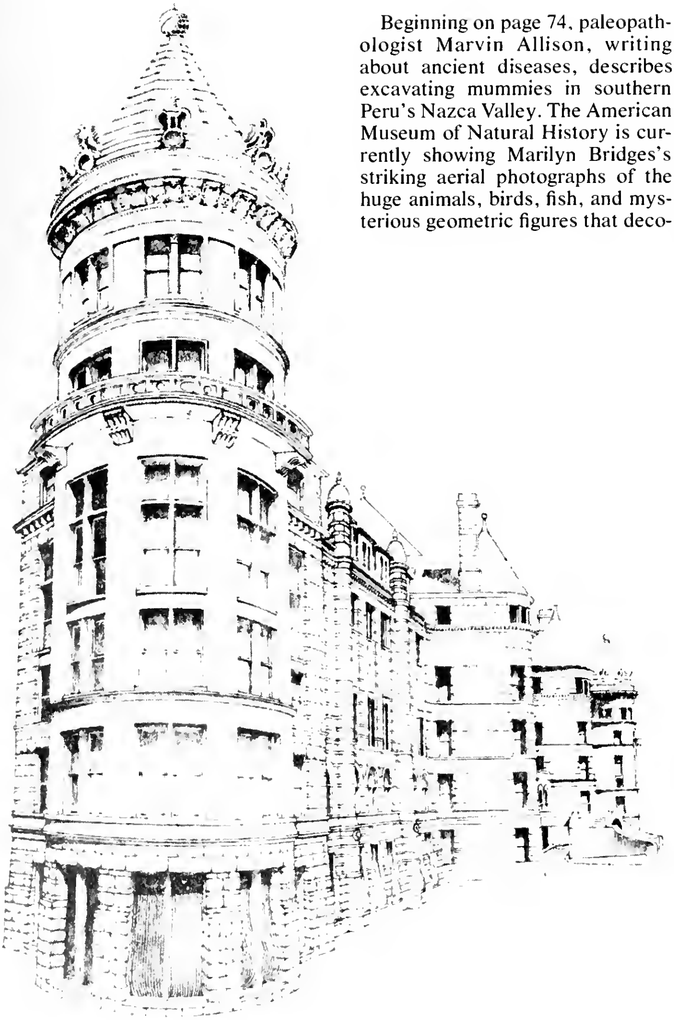

Beginning on page 74, paleopathologist Marvin Allison, writing about ancient diseases, describes excavating mummies in southern Peru's Nazca Valley. The American Museum of Natural History is currently showing Marilyn Bridges's striking aerial photographs of the huge animals, birds, fish, and mysterious geometric figures that decorate the vast, barren Nazca plain. Using this desert as a scratchboard, Nazca artisans drew the figures by lifting rows of red-brown stones—oxidized by the harsh sun—to reveal the lighter subsoil. This exhibit also includes some Nazca ceramics and textiles with motifs similar to the desert designs: interlocking spiders surround a bowl's rim, and fish, carrying human heads in their mouths, are worked into an elaborately knotted piece of cloth.

As we edited Allison's Nazca study for this issue, another mummy's riches, "Treasures of Tutankhamun," went on display at the Metropolitan Museum of Art. This event inspired us to find out about our own "mummies," the preserved birds and animals in the American Museum's dioramas, more accurately called habitat groups.

One outstanding group, the Hall of African Mammals, was designed by Carl Akeley (1864–1926), explorer, naturalist, and inventor. In the Museum's library, we found several versions of Akeley's autobiography, in which he says that when he first took it up, taxidermy involved "very little science and no art at all." He was set to work stuffing raw skins with "straw, excelsior, old rags, and the like" and mounting the stiff, unnatural results on frames of wood and steel.

Striving for more lifelike figures,

Akeley devised new methods. In the field, he would skin an animal and preserve its hide with salt and beeswax for tanning later. He carefully measured every part of the animal's body, saved the bones, horns, hoofs, and claws, and often made a plaster mold of the head.

Back at the Museum, Akeley, constantly checking against his original measurements, reassembled the skeleton to make an armature on which he would sculpt a clay model that showed the animal's every muscle. From a plaster mold of the clay model, he would cast a light papier-mâché manikin, over which the animal's skin, when it returned from the tannery, fit like a glove. Such a construction, if protected from museum pest—an insect that attacks mounted specimens—and kept in an airtight case, should last indefinitely. The Hall of African Mammals could not have been so realistically mounted before Akeley came along; it would be impossible to replace today—the animals are rare, and expeditions and taxidermy would be too costly.

Akeley believed that a proficient taxidermist, besides having some artistic sense and familiarity with anatomy, clay modeling, and tanning, should collect his own specimens: "Other people's measurements are never very satisfactory, and actual study of the animals in their own environment is necessary to making natural groups." In the field, Akeley and his fellow Museum preparators collected botanical specimens and recorded habitats via photographs, sketches, and even small-scale models.

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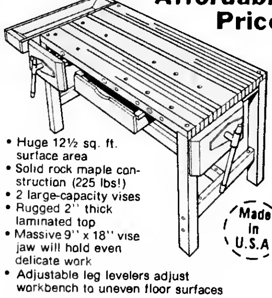

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When Akeley was in Africa working on the African Hall's water hole group, he attracted the appropriate animals by filling a drying water hole.

Recently, we walked through the Hall of African Mammals with Stephen Quinn, a 27-year-old senior preparator and artist in the Exhibition Department, who has also studied field biology. Since he is writing a book about the American Museum's diorama background painters, Quinn has been recording the memoirs and techniques of the few remaining veteran craftsmen of this unsung chapter of art history. According to Quinn, painters such as William R. Leigh, Francis Lee Jacques, James Perry Wilson, Robert Kane, and Matthew Kalmenoff are "Renaissance men, the only heirs of Michelangelo in an era that favored abstract painting."

Quinn pointed out that, like Michelangelo, a background painter had to use the mathematical principles of perspective to allow for distortion created by the curved canvas of a diorama. James Perry Wilson, who died in 1976, was responsible for one of our favorites, the Upper Nile group, whose background is packed with stories: a forest fire on the far bank, hippopotamuses yawning in the river, crocodiles sunning on the muddy flats. Quinn remarked that if some of Wilson's animals were removed from the curved wall and pressed flat, they "would look all stretched out . . . as though they were made of rubber."

In every habitat group, a painter's ingenuity is tested by the point where the foreground—composed of replicas of plant specimens and actual soil and detritus—meets the background. The painter has to fool the viewer by painting up to and merging with this foreground material. One animal in the African Hall, the okapi, lives in forests so dense that it escaped discovery until the early twentieth century. In its habitat group, overhanging branches were attached to the ceiling, and repeated in the background, to create an illusion of high, leafy canopies. In the Libyan Desert group, where a flat, monotonous landscape could have made tying background to foreground extremely difficult, Wilson broke the sandy stretches with a long shadow, cast from a rock outcropping on the left, over the antelopes, oryxes, and gazelles.

Quinn is about to begin work on his first big background (about twenty-three feet wide) for the new Hall of Peoples of Asia and admits both excitement and trepidation at the thought of treading the masters' footsteps. He feels that the American Museum's habitat groups are unrivaled, although Yale's Peabody Museum also has some outstanding dioramas because it hired Wilson and Jacques.

February Events

On February 3 and 4, the Museum will hold an **India Weekend.** Three free films will be shown on Saturday in the Auditorium, among them *Pather Panchali,* distinguished Indian director Satyajit Ray's story of a Bengali village family. On Sunday, at 2:00 P.M. in the Auditorium, the Theatre of the Open Eye will present two funny Indian animal fables for children. In *Welcome to the Holy City* a holy man escapes a tiger's jaws, thanks to a particularly thickheaded jackal. In *The Cobra and the Crows* two clever birds outwit a cobra who threatens their offspring. Tickets for the Sunday performances are available at the first floor information desk or call the Membership Office: (212) 873-1327.

The weekend of February 10 and 11 will be devoted to **Ancient and Modern Mainland China.** On Saturday at 2:00 P.M., two films—Joris Ivens and Marceline Loridan's *Impressions of a City,* filmed in Shanghai, and an NBC-TV special, *The Forbidden City*—will be shown in the Auditorium. At 3:30 P.M. on Sunday, the program will continue with films of the Museum's 1920s expeditions in China and two more films by Ivens and Loridan: *Behind the Scene at the Peking Circus* and *Traditional Handicrafts.* These and other programs during the India and China weekends are free with Museum admission. For further information about particular events, call 873-1330, extension 559 or 566.

There is now a special hotline—(212) 999-7777—for ticket information for **Pompeii AD 79,** opening April 22. Only Museum members may order tickets in advance, but there is still time to become a member and order tickets.

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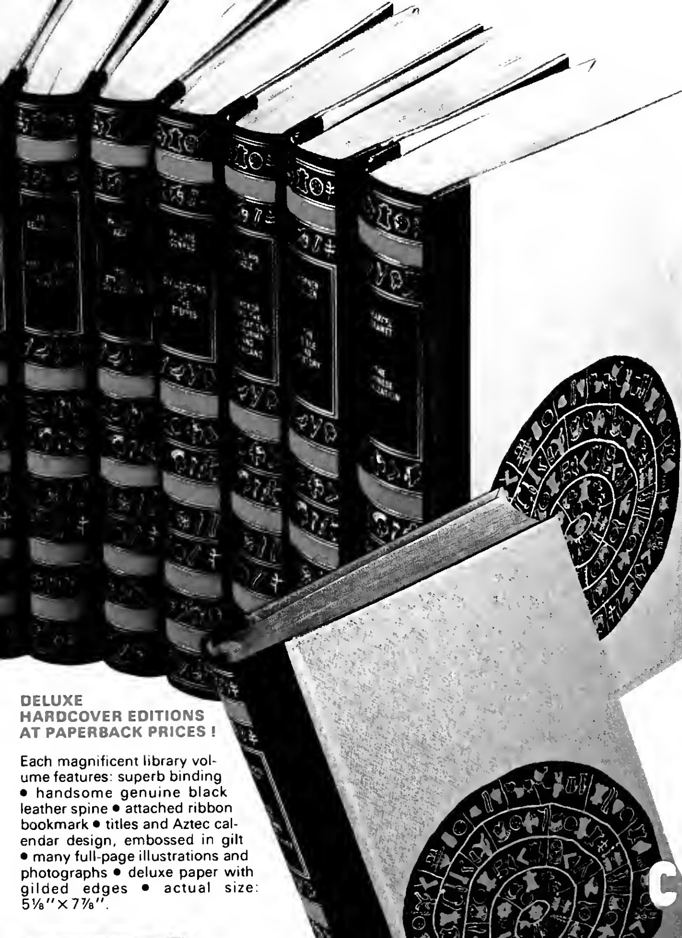

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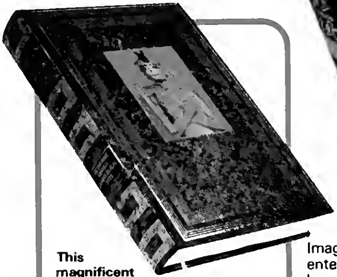

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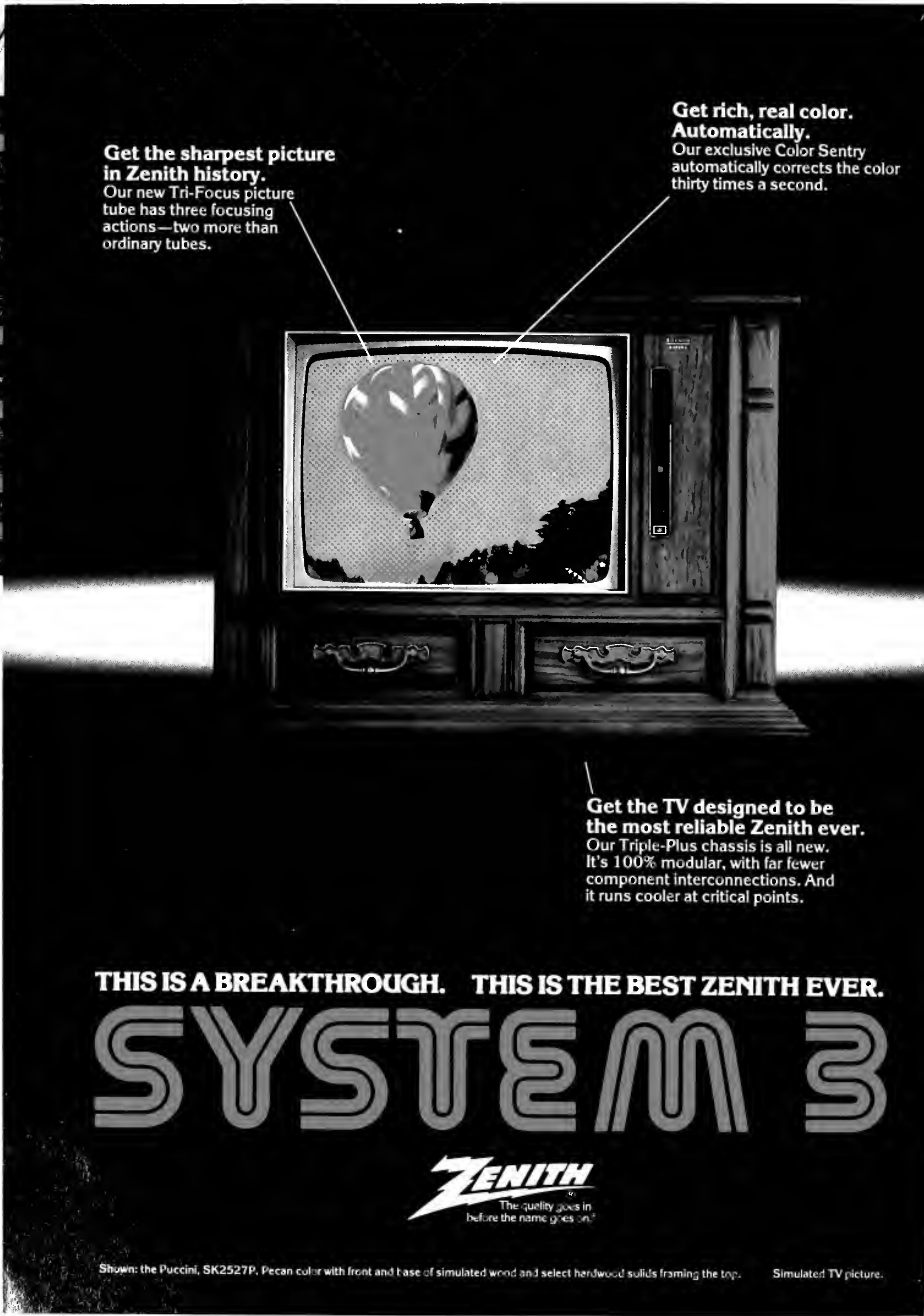
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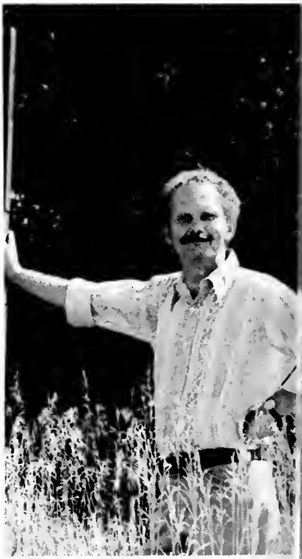
Authors

"I have been interested in the problem of civilization building for many years," writes **Robert G. Wesson**, "and it occurred to me that this is highly relevant to the question of possible extraterrestrial civilizations." A professor of political science at the University of California, Santa Barbara, Wesson recently spent a year as curator/scholar at Stanford University's Hoover Institution on War, Revolution and Peace. His specialties are political theory, comparative politics, and Communist politics. Over the years, Wesson has written many books and newspaper and magazine articles on these topics. Six of his books are in print.

Coauthors **Irwin D.** and **Marion C. Rinder** were working in Israel in 1973 when the Yom Kippur War aborted their project. So they chose peaceful Sweden for a study of the Lapps and their conflicts with national programs. While there they made a thirty-minute documentary film on the Swedish Lapps. Irwin Rinder, a professor in, and chairman of, the Department of Sociology at Macalester College in Saint Paul, Minnesota, and Marion Rinder, a registered nurse and anthropologist, find their complementary interests a good basis for collaboration. Their next project will be a study of the celebrated pilgrimage to Santiago de Compostela, the capital of Galicia, in northwestern Spain, and site of an imposing cathedral.



In the spring of 1971, while stroll[illegible] along the border of a local ma[illegible] **Roger M. Knutson**, professor of b[illegible]ogy at Luther College in Deco[illegible] Iowa, saw a skunk cabbage "mel[illegible] its way up through the last ice [illegible] winter." The sight jogged his mem[illegible] of a professor telling him that "m[illegible]bers of the same taxonomic family [illegible] flowers that heated up at the perio[illegible] full bloom." Knutson ran for a t[illegible]mometer and "has been following [illegible] plants ever since." He would lik[illegible] pursue his research of temp[illegible]ture-control mechanisms in skunk [illegible]bage over most of the plant's rang[illegible] North America and in Japan. M[illegible]while, he studies prairie restora[illegible] and keeps an eye on a small prairi[illegible] is developing in his back garden [illegible] on his five children.

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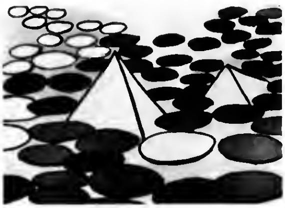

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Born in Barsinghausen, West Germany, **Bernd Würsig** received his Ph.D. from the State University of New York at Stony Brook. At present a postdoctoral research fellow in applied sciences at the University of California at Santa Cruz, he is investigating the behavior and ecology of the Hawaiian spinner dolphin. His fieldwork on the dusky dolphin was done in Golfo San José, off Argentina's Patagonian coast. **Melany Würsig,** his wife, coauthor, and fellow researcher, was born in Caracas, Venezuela. She works alongside her husband at the University of California, where she is a research assistant. Besides their common interest in dolphins and other marine mammals, the Würsigs enjoy scuba and skin diving, hiking, and photography.

The article on Prince Leopold Island is **Fred Bruemmer**'s ninth for *Natural History*. Widely published as a writer and photographer, Bruemmer has traveled to Africa, Europe, the Middle East, the Galápagos Islands, and Indonesia. His keen eye for the details of human and animal behavior and his perceptive use of the camera enable him to comment effectively on the worlds he traverses. His abiding interest, however, is the Arctic, its wildlife, and Eskimo. His wife, Maud, maintains their extensive photo archives.

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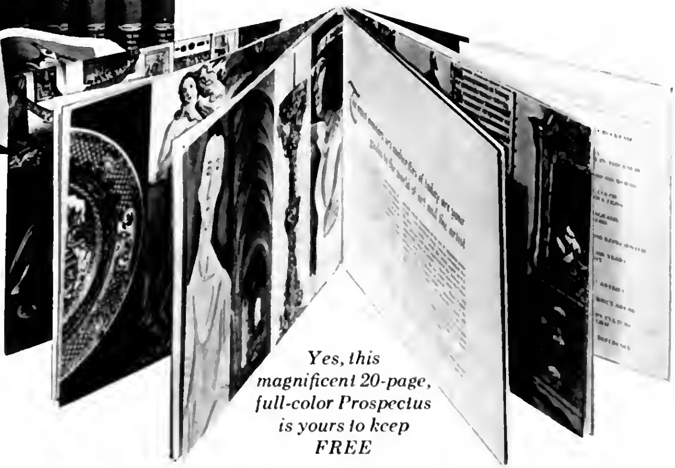

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Wrong Number?

A skeptic argues against the likelihood of advanced extraterrestrial civilizations

by Robert G. Wesson

Those who scan the skies for signals of extraterrestrial intelligence try to form a rough estimate of how many communicating civilizations there may be in our galaxy. The probable number they postulate is the total number of stars in the Milky Way, times the proportion of stars with planets physically suited for life, times the proportion of suitable planets generating life, times the proportion of biotas producing sufficiently intelligent organisms, times the proportion of intelligent species generating a high technological civilization. The probability is minute that such civilizations have been emitting signals that we might pick up.

The first number, that of stars in our galaxy, is the only factor known to a reasonable approximation—about 250 billion. The percentage accompanied by planets climatically suited for lifelike structures is guessed to be rather large on the basis of the nearby stars known to have invisible companions and on the supposition that most stars that resemble our sun have had a similar formation from gas and dust clouds and are hence likely to be circled by residual agglomerations called planets. However, almost seven-eighths of these stars are in the core of the galaxy and hence are subject to perturbations over a long period. In addition, more than half of them are double or multiple stars and therefore unlikely to have planets with stable orbits. Consequently, it is improbable that more than one percent of stars of our galaxy have planetary companions suitable for life. That comes to about 2.5 billion planets.

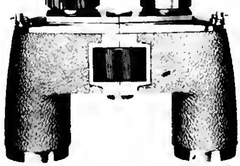
The accepted view is that life should have arisen on a large majority of such planets. A variety of organic substances have been detected in space and in meteorites. Exposed to an appropriate electric discharge, the probable components of the primordial atmosphere of the earth can be made to combine to form amino acids, nucleic acid precursors, and the like. Life on earth, however, apparently required more than a billion years to form bacterialike organisms, and it is doubtful that a creative process that demands a great deal of time is inevitable.

The condition that life develop an information-processing system at least equal to human intelligence (nothing inferior could construct a civilization) is even more speculative, but the likelihood is usually rated as high. In the evolutionary process, which is implied by the nature of life, there is a long-term tendency toward increasing complexity of organization because variation is perennially superimposed on existent structures. Additions are retained if advantageous, and they serve as a basis for further improvements. However, the extent to which evolution can be counted on to produce high intelligence may be questioned.

In many groups of organisms, complex responsiveness rises only to a certain level and then halts. For example, coelenterates (jellyfish and related forms) have been around for hundreds of millions of years and have produced large and complex organisms but no brains. Fishes have developed elaborate sensory equipment and an effective central coordinating system, but there is no reason to believe that more hundreds of millions of years of aquatic existence would raise their intelligence significantly. Porpoises, having returned to the sea, possess an impressive degree of intelligence, for reasons unknown, but it may be that in their way of life further intelligence would confer no advantage.

In land animals, intelligence may reach a maximum level in any given group or way of life beyond which further intelligence would not be evolutionarily useful. The smartest herbivores remain below the level of the brighter carnivores: catching prey is more challenging than escaping capture. Conceivably, additional information-processing ability would not be advantageous for four-footed predators. Marked growth of intelligence comes about, it seems, either in shifts into new environments or through the development of more complex coordination leading to new means of securing nourishment.

One may assume, however, that the vicissitudes of evolution on an earthlike planet, with continual changes of climate and topography, and hence ever new opportunities for life to occupy new niches, would probably lead to intelligence capable of toolmaking, symbolic communication, abstract reasoning, and record keeping, that is, to the potential creators of a technological civilization. What then are the possibilities, first, of the development of "civilized" life and, second, of a civilization advancing to an electronic level capable of making itself known across many light years? The chances are generally believed to be very high. But this belief owes much to the optimistic feeling that reason triumphs and



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progress is natural in a well-ordered universe.

Knowledge of human history and prehistory hardly encourages such optimism. Toolmaking humans hunted mammoths and cave bears for a hundred thousand years prior to the development of agriculture about 10,000 years ago. During this time brain size increased not at all, an indication that intelligence (assumed to be related to brain size) was no longer biologically selected. Why there was a sudden acceleration in the growth of culture and the increase of population in Neolithic times is quite mysterious. It may have resulted from the accumulation of inventions that created conditions for yet more inventions, or there may have been some fortunate conjunction of circumstances in the Near East that gave rise to the fundamentally new way of life based upon agriculture. However, the development of agriculture led to population densities that increased human interactions enormously. Once the cultivation of grains became known, the knowledge could easily and rapidly have spread from the Near East to China and even to the Americas, which were not entirely isolated even at an early date.

The likelihood of a tool-using agricultural creature developing city life is conjectural, but so far as we know it may be high. Our own past makes clear that a species of hunters can attain sufficient genetic endowments to become capable of many things not encountered in its primordial existence. These may include such diverse achievements as the domestication of animals, irrigation works, cities, governments, religion, art, literature, and mechanical vehicles. The leap from these attainments to a broadcasting civilization, however, does not necessarily follow. The historical record suggests that it may be extremely unlikely.

About a dozen civilizations capable of creating impressive buildings, admirable arts, literature that is still pleasing, and philosophy still worth studying have grown up more or less independently, but all except one—Western civilization—came to a halt and stagnated. On the broad canvas of history, up to the modern age the overwhelming majority of peoples did not progress technologically beyond a modest level, but instead were standing still, in many cases even regressing. Rather than digging ever deeper into the secrets of nature or learning how better to use natural forces, past civilizations tended to become more traditional and superstitious.

The progressive periods of history have been few and have generally come to a halt after several centuries. For example, the Sumerians in the southern part of Mesopotamia, thought to be the chief creators of civilization, made a host of inventions from about 3000 to 2300 B.C., including the potter's wheel, sailing ships, wheeled carts, cylinder seals, and the plow, to which oxen were harnessed. They evolved writing in a form (cuneiform) sufficiently satisfactory to survive for 2,000 years after them. They had well-organized states, temples, and schools. But after 2300 B.C. their region of Mesopotamia was conquered by a series of empires. Progress ceased, rationalism declined, and for almost two thousand years there was more impoverishment than enrichment in the area.

The story of Egypt is similar. Egyptian civilization, which owed much in its beginnings to the Sumerians, came close to its height early in the pyramid-building first dynasties of the so-called Old Kingdom at about 3000 B.C. Thereafter, Egypt became one of the most static of civilizations. Art styles went unchanged for centuries and the country became poorer and less capable of progress.

In India, the early Indus Valley civilization, the formative period of which remains poorly known, was singularly static from about 2300 to 1750 B.C. It was brought down by the Aryan invasions or perhaps invited the invasions by its collapse. There ensued a long dark age, followed by a period of intellectual ferment, philosophy, and discovery, centered at the fifth and sixth centuries B.C. This was the great creative time of Indian civilization; for the next two thousand years there was little but repetition and preservation with only secondary cultural additions.

Other geographical areas have seen a similar sequence. In Peru, for example, the level of art and production seems to have come to its zenith in the several centuries after A.D. 200; thereafter, a series of empires brought no advance up to the arrival of the Spaniards early in the sixteenth century. The course of Central American civilization seems to have been parallel, although the partial loss of Maya culture was more striking.

The main outlines of the evolution of Chinese culture are the same. The great creative era was the time of the "Warring States," expecially 500 to

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250 B.C. Then came a series of empires, designated in historiography as dynasties, with briefer interludes of division, up to the arrival in the nineteenth century of Western culture on a large scale. The China of A.D. 1800 was materially not far ahead of the China of the third century B.C., and its potentiality for scientific discovery was less. During two thousand years, the Chinese made a number of inventions, especially in periods between unifying dynasties—gunpowder and paper are the best known—but the population tended generally to become more tradition bound.

There is no reason to suppose that any of these static cultures, if left to itself for more centuries or millenniums, would have made a breakthrough to electronic civilization. On the contrary, the general tendency seems to have been toward more closed and uninventive societies. The Egypt of Greek times abhorred change and had long since come to a cultural dead end. We know little of the intellectual life of the earliest dynasties, from 3000 to 2600 B.C., but it must have been vibrant. About 500 B.C. India was an intellectual garden; for the most part it was a desert thereafter until brought into the sphere of modern culture. There was no room for experimentation in the rigid structure of the Incas, but in the same territory more than a thousand years earlier, the variety of pottery suggested a lively contest of ideas.

Old civilizations, it seems, tend to follow ancestral ways, becoming ever more ritualistic, more superstitious, more dominated by parasitic classes and the apparatus of rule, the landlords, priesthood, and officials—categories that merge in a hierarchical society. At the same time, mineral resources become increasingly exhausted or difficult of access and population growth may press on the means of subsistence, perhaps (as in the Near East) diminishing the land's fertility.

To awaken a stagnant civilization to new life and creativity, a great external disturbance, such as the Germanic invasions of the former Roman Empire, may be necessary. Such a rebirth is not common, and it becomes less so as the level of civilization rises. There have been some ten or twelve autonomous primary civilizations—Sumerian, Egyptian, Indus Valley, Mexican, Peruvian, Shang Chinese, Minoan, and others of comparable technological level. But only in three geographical areas—Greece, India, and China—did civilization rise to what might be called a classic level of sophistication. And only in the West has a civilization gone on to the level of indefinitely expanding science.

The development of culture and technology, in other words, does not represent simply an accretion of knowledge but requires suitable conditions and an appropriate social order, without which progress may be nil or negative. In some societies there are incentives for discovery, innovation, and independent thought; in others, conformity is better rewarded and change is generally or totally discouraged. We cannot fully define what causes some societies to be more innovative than others, but one generalization seems possible: civilization building has progressed chiefly during times of divided sovereignty in a pluralistic state system rather than under the aegis of a universal empire, that is, an empire that essentially monopolizes the area of its civilization, such as the Roman Empire or China under the great dynasties.

The most familiar example of this dictum is the decline from the highly creative world of the numerous classic Greek city-states to the nonprogressive, ultimately static, degenerative Roman Empire. The Greek city-states grew up in the centuries before 800 B.C. on the islands and peninsulas of the Aegean Sea on the fringes of Near Eastern civilization. The classic Greek world was a highly competitive one of hundreds of statelets that traded, competed in sports and art, and occasionally fought with each other. For a few centuries there was not only exceptional creativity in literature, science, and philosophy, but improvement in ways of doing and making things such as pottery, cloth, and steel. But larger states grew up on the edges of the Greek world, and Macedon, in particular, with the aid of Greek culture, was able to put an end to Greek independence. Ultimately the empire of Alexander the Great, king of Macedon, broke up into medium-sized sovereignties—Macedon, Syria, Egypt, Rhodes, Judea, along with many leftover city-states. This new, less divided, more imperial Hellenistic world was less original and vibrant than that of the classic Greeks, but it was still highly productive, especially in the natural sciences.

The Roman Empire, however, crushed science, not because scientific investigation was prohibited, but because the spirit of free inquiry passed with the spirit of freedom and science ceased to be rewarding. Greek philosophers inquired into the nature of things; Roman philosophers asked how to deal with the regnant order or how to accommodate to it. Technology was retained, insofar as it was useful, especially for the construction of the monuments in which the empire took pride, but little was added, even to architecture. Education deteriorated to formalism and study of the classics. Astrology, a legacy of the Near East that Greek rationality had left behind, was revived and replaced astronomy.

As generation succeeded generation, there was less and less innovation and less and less idea that anything could or should be new. Only in religion was the Roman Empire fairly creative, as people sought in the supernatural what was not to be hoped for in the terrestrial. The worship of Isis and Mithra, like Christianity, offered salvation (to be happy one had to be "saved" from earthly conditions), not by practical deeds or search for reality, but through ceremony and faith. The great controversies of the later empire were passionate wranglings over details of dogma. In sum, over a period of some six centuries, science declined and even practical learning decayed with it. Literacy, which had been general among the classic Greeks, became a rarity in the early Middle Ages that followed in the wake of the Roman Empire; and science did not recover its Hellenistic level until some 1,600 years after the Roman conquest.

With the breakup of the Roman Empire, the loosened society became responsive to change and discovery. Simple practical improvements, such as the stirrup, the horse collar, and the wheeled plow were introduced; and as early as the eighth century A.D. the West began to gain ascendancy in military technology over its neighbors with better armor, the crossbow, and the like, an ascendancy that has protected the West from external conquest to this day. The development of technology has continued in the Western world, although unevenly, for more than a thousand years, through the upsurge of scientific thought in the thirteenth century and the rise of modern scientific inquiry in the seventeenth century, down to today's computer age.

Continuity of growth over such a long period is unique in history, and it rests on very special circumstances un-

Please turn to page 18

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The Cordura Fine Arts Commission in cooperation with Douglas Dunhill, one of the nation's leading mail merchandisers, is pleased to present this important Memorial Tribute to the most popular American artist of the 20th Century, Norman Rockwell. Although Norman Rockwell died on November 8, 1978, his vast and varied artistic contribution will live on forever in the hearts and minds of the many Americans he painted with such unusual sensitivity, compassion and skill.

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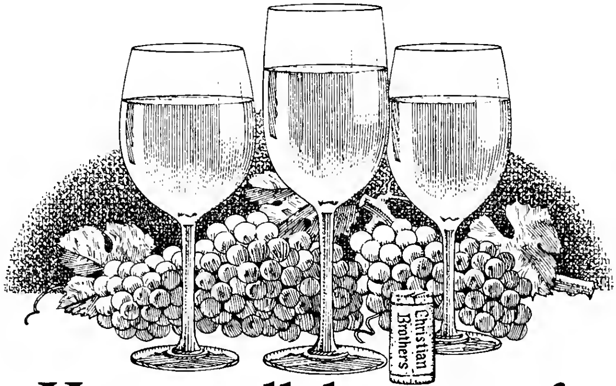

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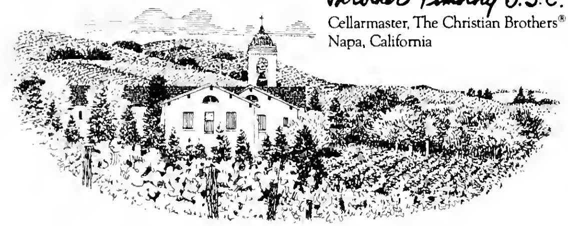

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likely to be matched on other planets. The key fact was that the Roman Empire could not be restored, in contrast to the situation in China, the Near East, India, and Peru, where the disorder consequent to the demise of an imperial order was overcome within a century or so by a new imperialism.

In all non-Western areas, once a great empire has ruled, it has not been possible to maintain a competitive international system for any extended period; and the longer the sequence of empires, the easier it was to reunify the domain. The empire of Alexander the Great was easily and permanently carved up because it was so brief—a mere eight years from the conquest of Persia to Alexander's death in 323 B.C.—that a divided world continued to be taken for granted in the Mediterranean area. But from time immemorial, where glorious empires have ruled, their ideological, political, social, and economic structures have been accepted as the natural way of the universe.

In the case of Rome, universal empire was also idealized for many centuries, and numerous would-be rulers of the world, from Charlemagne to Hitler, have aspired to resurrect the heritage of the Caesars. But because of fortuitous circumstances and accidents of history, each of the nine or ten strong efforts to assert rulership of the West has failed. Had any one of them succeeded, the open and innovative society of which we are the beneficiaries could not have developed.

One difficulty faced by early empire builders of the West was that the Roman Empire was a Mediterranean realm dependent on cheap maritime transportation. Roman legions went at least part of the way to almost any province by ship, and grain and supplies likewise came by ship. But control of the Mediterranean was lost in the fifth century to the Vandals and other invaders and again in the eighth century to the Arabs. It was recovered for Europeans by the Italian city-states of late medieval and Renaissance times, but the divided Italians built only commercial empires. Moreover, in the early Middle Ages the economic center of gravity of the West shifted to the north with the introduction of improved farming practices based on the more productive soils and moister climate of northern Europe. Hence, the empire could be restored only on a base of northern territories and overland transportation.

When the Holy Roman Empire (effectively founded in A.D. 962 by the German king Otto I) was set up as the temporal successor to the empire of the Caesars, it drew its strength from north of the Alps. But the universal Church, the spiritual heir of the Caesars, remained in Rome. There followed the centuries-long clash of spiritual versus temporal authority, which enlivened the Middle Ages, kept anyone from total dominion, opened minds, and permitted local powers to assert themselves. The counterbalancing of two institutions claiming supreme authority—one temporal, one spiritual—made possible the freedom of towns, the eventual rise of estates and parliaments, and the affirmation of the nation-states' right to existence.

From the beginning of the revival of trade and town life in the ninth and tenth centuries, hundreds of political units across Europe, from kingdoms and duchies down to bishoprics and towns, were able to assert some degree of independence. For about five hundred years, from the mid-tenth to the mid-fifteenth centuries, the life of Europe, its industry, trade, and arts, was dominated by free and semifree towns. There were many constellations of towns, mostly small republics, in northern France, eastern Spain, the Low Countries, western Germany, and Italy. The Italian towns were the freest because of the protection of the papacy, which resisted outside rule without being able to impose its own, and Italian city-states lasted longest and prospered most. In the Renaissance these small political entities dominated Europe economically and intellectually.

Material progress and inventions, such as artillery, however, favored the consolidation of larger political units. After the mid-fifteenth century, the nation-states—France, England, Spain, Portugal, and the Netherlands, followed a little later by Prussia, Austria, and others—became the masters of Europe. Monarchs integrated towns and feudal vassals into centralized states. But unpredictably, unification halted at the level of the nation-state, despite enormous improvements in the means of warfare, transportation, and administration. Only in the middle of this century were the European nation-states partially superseded. Thus, five centuries of an open international system, built on the achievements of the Middle Ages and the Renaissance, provided an environment for the germina

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tion and flowering of the scientific-technological revolution we are currently in the midst of.

This condition of large, contending and interacting sovereignties at a level of advanced civilization has been placed in jeopardy many times, as changing circumstances permitted one power or another to reach for hegemony. Both Charles V, Holy Roman emperor (1519–58), and his son Philip II, king of Spain (1556–98), seemed to have ample resources in their European and overseas dominions to make themselves monarchs of Europe, but they were frustrated by lesser nations defending their independence. The balance of power might have been overthrown in the first half of the seventeenth century if the imperial side had won the Thirty Years War, as it very nearly did. Following that war Louis XIV (1643–1715), who saw himself as potential sovereign of the universe, might well have made France master of Europe if his generals had been more successful in several wars. Napoleon for a time seemed to have succeeded in making the lands between Russia and England virtually into a single political society, but he was ultimately defeated because he could not conquer those powers.

Despite ambitious conquerors, stabilizing influences prevailed in the Western world of nation-states until this century. Geography has doubtless been the single most important factor in maintaining the dividedness of Europe, just as the dividedness of the islands and peninsulas of Greece made classic Greek civilization possible. Mountains, especially the Pyrenees, form several stable natural boundaries. The peninsular character of Italy and the insular position of Sweden have also been important. Most crucial has been the moat protecting Britain. After England lost its continental holdings in the fifteenth century, it adopted a policy of protecting its independence by preventing the unification of the continent facing it. Hence England fought many wars to sustain the balance of power, frustrating the ambitions of Louis XIV and Napoleon, as well as their predecessors and successors.

The bogs of Holland made possible the independence of that country, and the Netherlands, like England, was a powerful defender of the principle of freedom of nations. Without Swedish intervention, the Protestant anti-imperialists would surely have lost the Thirty Years War. It is significant that in Eastern Europe, where geographical divisions are generally less clear-cut than in the West, nation-states have been less stable, there has been less political freedom, scientific and technological progress has lagged, and multinational empires have prevailed.

By this century, the manifold improvement of transportation had largely overcome divisive geography, and the unification of Europe could hardly be avoided by Europeans. But by this time the spreading of the industrial revolution had raised great new states—America and Russia—so that the balance of power ceased to be merely European and there could be no effectively universal empire without overcoming those powers.

Various cultural factors also reinforced the individuality of the nation-states. The Reformation, in large part an affirmation of the independence of nations, triumphed where supported by the state, and its effect in both Protestant and Catholic Europe was to affirm the power and legitimacy of the secular authorities. The development of separate national languages—the nation is often defined linguistically—provided a basis and right for separate governments. From the beginning of the sixteenth century, overseas colonization distracted the major powers to a large extent from territorial ambitions in Europe—wars for a border province were less attractive when huge expanses beyond the seas could be had for little exertion.

The industrial revolution would at least have been much delayed if Britain, one of the most progressive and commercially minded powers, had not possessed good deposits of coal and iron within easy access of each other and of water transportation. These circumstances opened the way for the development of a large-scale iron and steel industry. Charcoal, an earlier source of energy, was a limited resource, and no heavy industry could afford to transport coal and iron ore more than a few miles by animal cart. The industrial revolution in turn made possible the construction of railroads, which facilitated the industrialization of the continent.

One may question whether the Hellenistic states, even if they had not fallen to Roman legions, could have advanced to modern industry in the face of their deficient natural resources. Without a large-scale energy source—coal is generally lacking around the Mediterranean and forests

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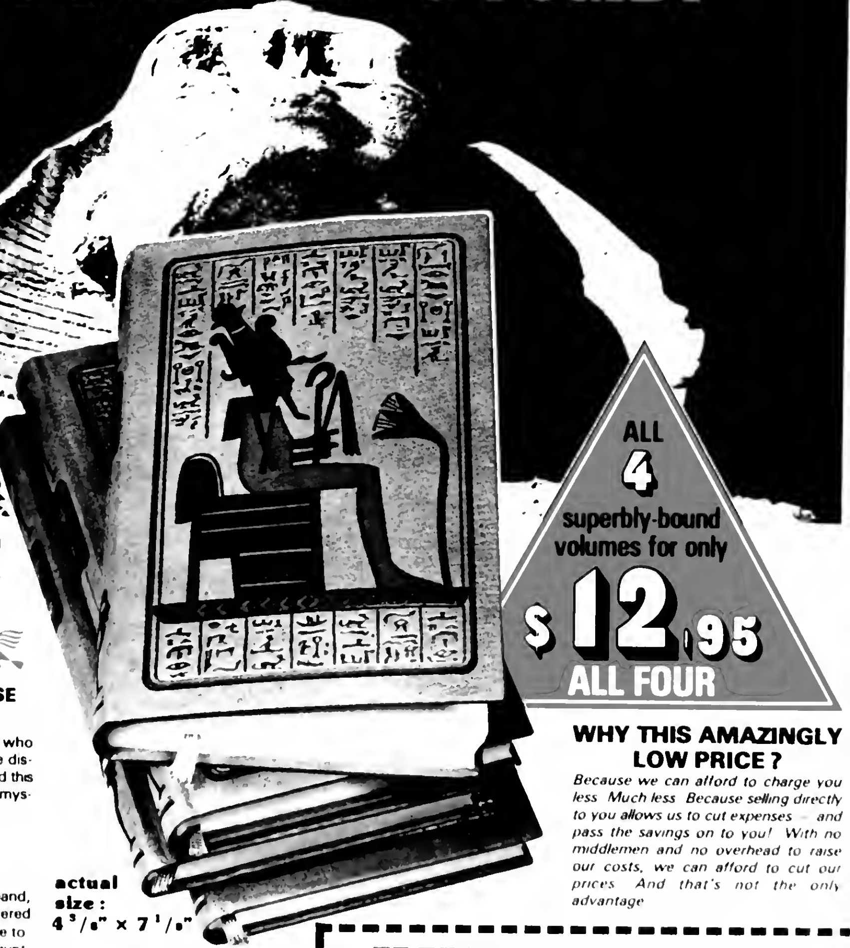

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there were even more inadequate than in the northern parts of Europe—the science that flourished at Alexandria and elsewhere in the third century B.C. would probably have lost momentum and eventually come to a halt. To this day, industrialization is feeble in the chief territories of Hellenistic culture—Greece, Turkey, Syria, Egypt, and adjacent lands.

The outburst of modern science has thus been made possible by a rare conjunction of circumstances. How rare the evolution of science may be cannot be guessed without more knowledge of life-bearing planets. But any estimate should consider that in the long term the development of technology has almost always generated political conditions inimical to innovation, free inquiry, and the development of technology. Civilization building has, except in the European case, turned itself off at a level far below the electronic.

This is deductively understandable. A civilized society, in which humans can think about nature and in which innovations may be proposed and adopted, requires an ordering and controlling state. On the other hand, society must be so structured as to permit or encourage attacks on accepted ways of thinking and doing. Original thinkers and inventors are unwelcome deviants in strongly ordered states. Consequently, innovative thinking and action can prosper only if there is a suitable balance between order and freedom. This balance is possible only if one political power is offset by other political powers. In practice, such offsetting has meant the division of sovereignty within a sphere of interacting independent states.

But if the balance between order and authority is productive, releasing minds to make discoveries that become the basis for still more discoveries, it also places new tools in the hands of political powers. There are always some who are prepared to use available tools to enlarge their own powers. This has meant attacks on the independence of states and ultimately on the international order, which checks the freedom of action of all rulers.

Destruction of the international order and establishment of a monopolistic state, however, destroy the environment for innovation. The rulership of a universal empire is conservative, because it has attained its supreme goal. In the desire of the elite to preserve its position, institutions and mental faculties become frozen. Climbing the ladder of power by manipulating the social and political order becomes virtually the only way to personal advancement, as it was under the imperial Caesars and the Chinese emperors. The imperial civilization becomes mentally calcified, bound up in customs of ever growing antiquity.

There is thus an intrinsic contradiction between intellectual progress and the empire building that intellectual progress makes possible. The situation is not saved by postulating an indefinite time span. Old civilizations, unless shattered from without, only grow older and more feeble. Over a very long time, there would presumably be genetic adaptation because the conformists and political careerists could reproduce themselves more effectively than those given to questioning and disturbing the routine. The intellectually inventive are not usually the biologically prolific.

Thus the sequence, loose political system to technological progress to general and ipso facto authoritarian empire, has often been repeated. Only the West has thus far escaped this trap through almost miraculous conditions. When, after half a millennium of progress, the viability of the free cities of the West was undermined, they were replaced by middle-sized nation-states, much as the Greek city-states gave way to the sizable Hellenistic kingdoms. But the Hellenistic powers flourished creatively for only about a century and a half before being swamped by Roman power. In the Western case, another set of extraordinarily favorable circumstances enabled the nation-states to preserve independence for another half millennium. The European nation-state system, which was in turn undermined by technological progress in the eighteenth and nineteenth centuries, gave way, not to universal rulership, but to a new and still broader world system, namely, the present Western-dominated world order.

The odds that another creature like *Homo sapiens*, with individual and social drives and capacities, would attain an electronic civilization may be comparable to those of winning a lottery. Conceivably, intelligence capable of developing a civilization might evolve in different ways on other planets. But if we assume evolution operates everywhere in basically the way it has here on earth, this implies individualistic beings, selfish or at least group-selfish, with an effective but not rigid social organization. Civilizations cannot be built by instinct. They require innovation based on insight and experimentation carried out against a background of knowledge. There is, then, an intrinsic conflict between the individualism of those who advance civilization and the social order indispensable for higher culture. Any conceivable development of civilization must be beset by difficult relations between the social order and the individual, who is adapted by evolution for a very different kind of society. In all probability, only an extraordinarily favorable set of accidental conditions can make possible a social order in which the intrinsic conflicts are creatively contained; and the difficulties multiply as the artificial environment diverges ever more from that in which the intelligent creature evolved.

In sum, the likelihood of an intelligent creature attaining an electronic or higher civilization may be much less than is often assumed, and the number of such civilizations to be expected in our galaxy is therefore correspondingly reduced. If one guesses that 2.5 billion planets have physical conditions suitable for life, this number may be rather optimistically multiplied by four-fifths as the fraction of planets on which life develops and by one-fourth as the fraction of these on which humanoid intelligence develops, for a total of 500 million. A reasonable guess is that not more than one percent of these, or 5 million, would be likely to achieve broadcasting capabilities. The question then remains, during what fraction of the life of the planet would such civilizations make broadcasts?

If one applies the logic of the preceding discussion, and also notes that change is enormously accelerated as the technological level rises, one might suppose that such broadcasting civilizations could last for two hundred to five hundred years, or for 1/25,000,000 to 1/10,000,000 the life of the planet. On this basis, the expected number of functioning electronic civilizations like ours would be one per two to five galaxies like ours. Only if we assume that high civilizations can somehow stabilize themselves for very much longer time spans without losing their curiosity and scientific capacity, as no earthly civilization has been able to do, would it seem likely that we have extraterrestrial neighbors capable of communicating with us. It may therefore be a very lonely universe. □

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by David and Marcia Pimentel

The Risks of Pesticides

They are more hazardous and probably less effective than methods that do not call for chemicals

The earth's enormous number of plant and animal species, including human beings, form a huge recycling system. All species function separately and together to keep life-supporting elements—oxygen, carbon, hydrogen, nitrogen, phosphorus, and other nutrients—moving throughout the environment. Hence, the vast variety of animals and plants is vital to human survival; people cannot get by with crop plants and livestock alone. Unfortunately, no one can predict just how many species can be exterminated before humans begin to feel the impact of the loss. Interactions and interdependencies operating within the earth's natural ecosystems are so complex that tampering with any one may cause irreversible harm.

Yet some effort must be made to manipulate ecosystems so that we can control the numbers of those species that are considered pests because they destroy food and fiber or spread diseases such as malaria. The central dilemma, however, remains unchanged: attempts to control pest species with pesticides or biological or cultural controls may also result in the destruction of valuable species and cause other environmental problems.

Certainly, the losses caused by pests are considerable. In spite of chemical and other controls, an estimated one-third of all crops in the United States is lost annually to pests: 13 percent is lost to insects; 12 percent to pathogens; 8 percent to weeds. Throughout the world, about 35 percent of all crops is lost to pests before harvest; another 15 percent is lost after harvest, much of it to rats. Such losses not only deprive people of valuable food and fiber, but also cost money and energy.

In the United States, during the last three decades, crop losses to weeds have declined, primarily because of better herbicides and changes in the ways and times of planting and harvesting crops. Over the same period, losses to plant pathogens, including nematodes, have increased only slightly, thanks to the more intelligent use of fungicides and the breeding of more resistant plants.

But, alarmingly, during the same period, crop losses to insect pests have nearly doubled, despite a tenfold increase in insecticide use and the availability of more and better insecticides. At present, the impact of this loss has been effectively offset by the planting of higher yielding varieties of crops, increased use of fertilizer, and more efficient harvesting. But losses to insect pests cannot be offset only by crop breeding and other farming methods. Because crop plants have a finite number of genes, there is a limit to the ways plant breeders can increase crop yields. For example, breeding resistance to an insect or a pathogen into a plant usually has a price, often in the form of reduced yield. And only a limited amount of fertilizer can be used before it becomes toxic to the crop and reduces yield. Furthermore, the production of nitrogen fertilizers, which are more efficient than manure on large acreages, requires large amounts of fossil energy. One-quarter gallon of petroleum is used to manufacture one pound of fertilizer. To rely on nitrogen fertilizers is to rely on a finite natural resource that is being rapidly depleted.

Since 1945, there have been several major changes in American agricultural practices that can account for the near doubling of crop losses to insect attack in spite of increased insecticide use. These changes include the planting of crop varieties that were bred for high yield, but turned out to be susceptible to some pests. The inadvertent pesticidal destruction of certain pests' natural enemies has resulted in some pest outbreaks. Because insecticides have destroyed natural enemies of the boll weevil and because some insect pests have developed resistance to these insecticides, cotton crops now require about 50 percent more insecticide to combat budworms, bollworm caterpillars, and other insects that were not originally problems.

In some apple orchards, insecticides have eliminated coccinellid beetles (ladybugs) and other predator and parasite populations that controlled mites and aphids. Sometimes, these plant pests increased twentyfold above the population levels found in untreated groves and orchards, where other predators effectively controlled pests. Since 1948, many insect and mite pests have dramatically developed resistance to pesticides. The number of resistant pests has actually increased to nearly four hundred species.

The use of pesticides has also altered the physiology of certain crop plants, such as corn, making them more susceptible than ever to insect attack. A few corn herbicides, 2,4-D in particular, render corn more susceptible to pathogens and insects such as the corn leaf aphid. In fields treated with usual dosages of 2,4-D, corn leaf aphid pop-

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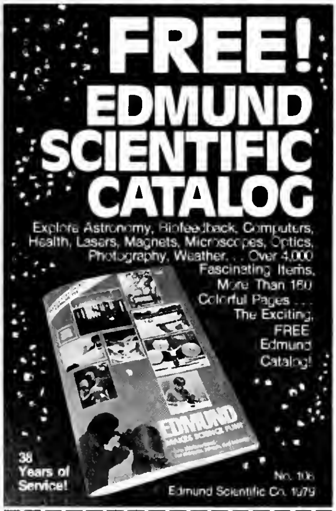

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ulations have numbered more than three times those on untreated corn. Corn exposed to 2,4-D also suffered one-third more attacks from European corn borer, another pest. Laboratory studies have shown that corn borer pupae growing on plants exposed to 2,4-D were about one-quarter larger than those on untreated corn plants, and moths from these larger pupae produced one-third more eggs. Corn exposed to 2,4-D was not only more susceptible to aphids and borers, it also had more southern corn leaf blight infections and larger corn smut galls than did untreated corn. Evidently, some herbicide treatment of corn and other crops may increase risks of disease and insect attack. On nearly two-thirds of American corn acreage, rotation of corn crops with small grains, alfalfa, or soybeans successfully prevents corn rootworm.

Since 1945, because of labor costs, farmers have been less conscientious about destroying infected crops and crop residues left in fields—thus enhancing pest problems. The Food and Drug Administration lowered the tolerance levels of insects and insect parts in food crops, while food processors, retailers, and consumers concurrently raised their cosmetic standards, especially for fruits and vegetables. As a result, orange and grapefruit growers had to begin combating pests such as rust mite, which does not harm fruits but does mar their skin. In other words, farmers and growers had to use more insecticide to make certain their crops met these high standards for market.

Yet another change in agricultural practices has encouraged pests. During the past thirty years, farmers have begun growing particular crops in climatic regions where they are more susceptible to insect attack. Traditionally, potatoes have been grown in the western mountain states, where even now only 65 percent of the crop is treated with insecticide. But farmers in the southeast now treat 100 percent of their potato crop because pest problems are severe in this region.

The United States began to rely heavily on large amounts and frequent applications of petrochemical pesticides after World War II, when newly developed substances, notably DDT, seemed to offer an easy, reliable, and until the recent rise in oil prices, cheap method of pest control. Of the nearly one billion pounds of pesticides used annually in the United States, more than three-fourths is applied to agricultural crops, while homeowners, industry, and governmental agencies use the remainder for diverse pest problems. Fifty-one percent of agricultural pesticides are herbicides used to control weeds, 35 percent are insecticides, and the remainder are fungicides.

Interestingly, these crop pesticides are unevenly distributed. For example, about half of all insecticide used in agriculture falls on cotton and tobacco, two very valuable crops worth about $4,000 an acre. Among food crops, the largest amounts of insecticide go to fruits and vegetables. These crops, which occupy smaller acreage and require more labor, are more valuable than wheat, oats, or barley, which are worth about $90 to $100 an acre. For the same reason, 45 percent of all herbicide is used to control weeds in corn fields, and nearly 66 percent of all fungicide is applied to fruit crops.

Other important patterns show up when pesticide applications are related to particular crops treated. While cotton receives nearly 50 percent of all insecticide used in agriculture, about 10 percent of cotton acreage—mainly on the high, dry plains of Texas, where the boll weevil is not present—receives little or no insecticide. Obviously, these untreated, relatively pest-free acres must produce enough cotton for farmers to earn a profit.

Of the nearly one billion acres of pasture and agricultural land in the United States, only 17 percent is treated with herbicide, 6 percent with insecticide. Even when pastureland is discounted, and each percentage roughly doubles, the acreage treated is surprisingly small considering the tremendous amount of pesticide applied each year. Only a few food crops, mainly valuable fruits and vegetables, have more than 75 percent of their acreage treated with insecticide. In contrast, many acres of small grains and pasture receive little or no insecticide treatment.

If American farmers used no chemical pesticides, substituting instead a few biological and cultural controls, food-calorie losses would amount to only 5 percent. There would be ample supplies of cereal grains and other staples, but decreased supplies of such foods as apples, peaches, plums, onions, and tomatoes.

The one billion pounds of pesticide applied annually is aimed at only about 2,000 pest species—representing one percent of the total number of plant and animal species known to exist in the

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United States. Methods of applying pesticide are very inefficient: most simply drifts away, and farmers compensate by using large amounts. If pesticide could be applied only to pests, less than one percent of the chemicals now being used would be necessary to control pest populations.

Of all methods of applying pesticide, dusting and spraying from aircraft is particularly wasteful and is also responsible for other species inadvertently being poisoned. Even under ideal conditions, only 40 to 80 percent of pesticide dropped from aircraft reaches its intended crop. Considering that about 65 percent of all agricultural pesticide is applied by aircraft, this use of expensive material creates a major environmental problem.

One direct detrimental effect of such application is the reduction or elimination of beneficial predacious and parasitic insect populations. Indirect effects of pesticides can be diverse, far-reaching, or obscured by other environmental factors. For example, the numbers of a nontarget species may decline because of pesticide contamination or because of severe weather conditions. The ways in which insecticides and herbicides travel through the environment and the dosages that eventually reach beneficial species often cannot be easily traced.

In the 1950s, when some raptorial bird species such as eagles and falcons began to decline in habitats contaminated with chlorinated insecticide residues, wildlife biologists suspected that these substances were having an adverse effect on the bird populations. But increased urbanization, particularly the spread of suburbs in the northeastern United States, could have been contributing to bird population decline. Proof that DDT and other insecticides were the culprits required extensive laboratory tests, in which measured amounts of DDT, its metabolite (DDE), and dieldrin were fed to American sparrow hawks, until levels of the insecticides were as high in these birds as in the wild bird population. The hawks produced eggs with significantly thinner shells, resulting in a significantly greater loss of eggs. Thus, laboratory evidence substantiated field observations, leading to the conclusion that in certain localities residues of DDT and DDE were contributing to population declines in some bird species. But precisely how much decline was due to pesticides and how much to urbanization remains in question.

Again in the 1950s, the decline of lake trout in Lake George, New York, and other nearby lakes also showed the complexity involved in measuring indirect effects of pesticide. For several years before and during the observed decline in lake trout populations, about 10,000 pounds of DDT had been applied yearly to portions of the Lake George watershed to control black fly, whose bite plagues vacationers. Over the years, DDT had found its way into the lake, but in amounts considered small. Although DDT was found in both adult lake trout and their eggs, the mature lake trout appeared unaffected and their eggs hatched normally. Yet the lake trout population continued to decline until scientists discovered that the newly hatched fish were highly sensitive even to low levels of DDT in egg yolk, on which they live before they are ready to feed on their own. Mortality in the fry was 100 percent at low levels of DDT in egg yolk. Thus, the reason for the decline in the lake trout population in Lake George was obvious. This case also points out that there is much variation in response to pesticides—differences in species response as well as in stages of development in the same species.

Another grave concern about pesticide use is its deleterious influence on human health. The Environmental Protection Agency calculates that every year about 45,000 individuals are poisoned to some degree by pesticides. An estimated 3,000 are poisoned seriously enough to require hospitalization, and an estimated 200 die annually. To date, none of these reported poisonings has been attributed to eating food crops properly treated with pesticides. Instead, fatalities have occurred among people who handle pesticides—farmers, crop dusters, and workers in factories that manufacture these chemical pesticides.

Human deaths related to pesticide are particularly distressing. Although chemicals are often called the best way to control pests, biological and cultural controls are, in fact, equally effective. These alternative controls reduce pest populations through human manipulation of the pest and/or its environment. For example, since 1780 the Hessian fly has been a serious pest in the United States. Control on about one-third of fly-infested wheat fields has been achieved by developing and planting wheat varieties resistant to the pest. Fly control on a large part of the remaining acreage has been accomplished by delaying planting until most of the newly emerged Hessian flies have died. Breeding resistant plants and using the simple cultural control of delayed planting has kept wheat damage to a minimum.

Another example of the success of nonpesticide methods is the control of the spotted alfalfa aphid and the alfalfa weevil, two major pests. Of the alfalfa grown in the United States, about one-third is infested with the spotted alfalfa aphid. This pest can be controlled primarily by its natural enemies and by planting alfalfa varieties resistant to the aphid. Although nearly half the alfalfa crop is attacked by the alfalfa weevil, this pest is now successfully controlled by natural enemies and alfalfa culture practices. Early cutting allows alfalfa to grow up again, eliminating many weevils; alfalfa allowed to grow harbors a larger generation of these pests.

Several insect pests that attack citrus and olive crops have been effectively controlled by introduced parasitic enemies. Screwworm fly, a serious livestock pest that used to cause cattle ranchers annual losses of $30 million, has been successfully controlled through the release of sterilized males. The mating of sufficient females with sterile males will result in insufficient numbers of fertilized females to maintain the population.

In contrast to insects, still largely controlled through insecticides, plant diseases are now controlled mainly by biological means. Most major crop varieties have been developed to incorporate varying degrees of resistance to one or more major crop disease. Up to 98 percent of small grains acreage is planted with resistant varieties. More than 90 percent of potato varieties have some resistance to potato scab and blight.

Even before breeding techniques were refined, farmers tried to insure some degree of disease resistance by only using seeds from healthy plants. Nowadays, most bean, pea, and potato seed planted in the United States is disease free. Nearly all fruit trees are certified disease free. Besides using these strategies, growers have been able to control some crop pathogens by eradicating alternate hosts. Removing a host plant will affect the environment, but these side effects need not cause harm to humans. Some black stem rust of wheat has been controlled by elimination of barberry, a plant that harbored the rust. In peanuts, white mold can be reliably controlled by burying the sur-

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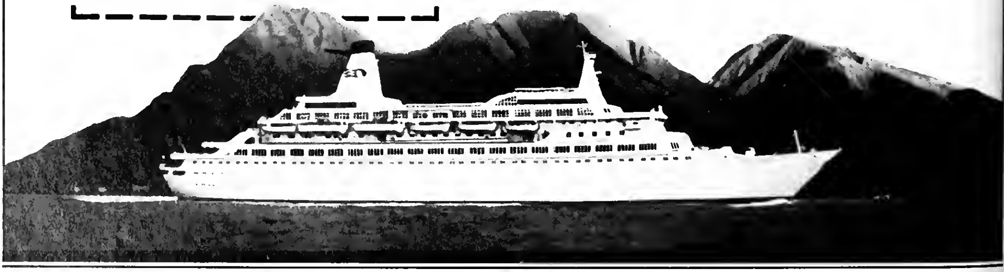

face crop remains with deep plowing.

As in the case of corn rootworm, crop rotation is a major cultural control for many crop diseases. If cabbage is continually planted in the same field, the clubroot pathogen population builds up in the soil. But if cabbage is rotated with a noncole crop, the pathogen population declines so that cabbage can be safely planted once more.

Although the use of herbicides—less costly than laborers or tractors—has been escalating in this country, most weed control is still accomplished by means of tilling, cultural practices, and sometimes biological controls. In the early 1940s, when several million acres of California range and farm land were severely infested with the Klamath weed, the introduction of an enemy, a leaf-feeding beetle found in Australia, resulted in excellent control. A relatively simple crop management technique, such as the timing of rice field flooding, will often control some weed species. In rice fields in the United States, Southeast Asia, and elsewhere, early flooding destroys young weed seedlings before they can establish themselves.

These successes notwithstanding, whenever species in the natural ecosystem are manipulated by either chemical or biocontrol methods, environmental problems are a possibility. All pest-control methods have to be carefully researched before being put into practice. If all aspects of the new method's impact are not clearly understood, serious trouble may result. An example of one poorly conceived biocontrol method was the introduction in the 1870s of the Indian mongoose into Jamaica, Puerto Rico, and other West Indian islands to combat rats on sugar cane plantations. Although the mongoose initially seemed highly effective, the rat population soon returned to pest levels. Farmers found mongooses were preying heavily on their chickens, and in the early 1940s the animals were incriminated as the vector of, and reservoir for, rabies. In addition to these new problems, the question remained as to why the mongoose, an animal that usually controlled rats, was suddenly ineffective.

At the time the mongoose was brought there, the rat population of the Caribbean Islands consisted of two species, the Norway, or brown, rat and its natural competitor, the tree, or black, rat. The Norway rat was then the dominant rat species because it generally drives out the tree rat and all rival rodents. Since the Norway rat nests in the ground, the introduced mongoose had ample opportunity to attack and control it on sugar plantations. Once the dominant species was controlled, tree rats easily became dominant since they no longer had a competitor. The mongoose, which cannot climb, could not reach the tree rat, and hence itself developed into a pest. On islands where the mongoose was not introduced, the Norway rat remains the dominant species.

Besides preying on chickens and carrying rabies, the mongoose destroyed ground-nesting birds and lizards. The reduction in lizard populations apparently resulted in an increase in populations of a sugar cane beetle. This example illustrates not only how far-reaching the effects of a biocontrol method can be, but also the importance of studying an entire established ecosystem before introducing any new species.

Undoubtedly, some plant and animal species that destroy crops and livestock and are vectors of human disease will be considered pests. Various strategies will continue to be developed and used to control pest numbers. But control methods of the future can profit from past mistakes. Because of their far-reaching effects, chemical pesticides should be an emergency weapon. When pesticides are the only option, methods of application should be improved so that only the pest species are exposed. Careful use of well-designed biological and cultural methods promises control with a minimum of deleterious impact on human beings and other nonpest species.

David Pimentel is professor of entomology and agricultural sciences, and Marcia Pimentel is senior lecturer in nutritional sciences at Cornell University, Ithaca, New York.

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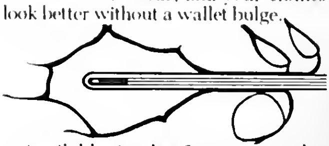

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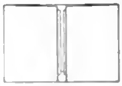

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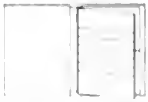

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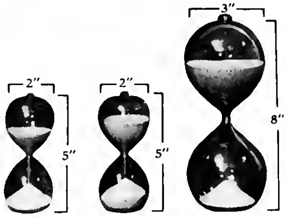

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Cod Piece

Salt cod in this country is a neglected resource

In Boston, they eat its cheeks for breakfast. In the Levant, they beat its eggs to a pulp and smear them on bread. Little children everywhere used to have to gulp down the noisome oil from its capacious liver. Its young, called scrod, were the folkloric delicacy of East Coast Catholics in the days of meatless Fridays, and this custom led to a famous, if scruffy, joke about a man from Massachusetts in Chicago on business looking for his favorite fish and finding only mockery.

Gadus morhua is a fish of many humiliations. Even the etymology of its vernacular English name, cod, is an embarrassment. No one is really sure where the word came from, but in ordinary parlance it long ago became confused with its probably unrelated homonym, meaning variously testicle bag and scrotum. This mix-up produced mere wordplay, and the endless Elizabethan punning on cod found an honorable place in the pages of Shakespeare.

But far and away the worst treatment the cod has received has been at the hands of food processors. I am not thinking of fiendish modern Dr. Sivanas injecting the big North Atlantic fish with hormones or sesquipedalian organic chemical preservatives with such names as 29-X butylpiscatocarcinogen. I have in mind villagers in Newfoundland and Norway and Iceland who have for the past several centuries been preserving cod, salting and drying it until it turns into ugly, stiff, boardlike, almost petrified gray slabs. With the advent of refrigeration, the need for salting or drying cod has greatly diminished. But the taste for this fish of the north lives on unabated among the peoples of the Mediterranean and their descendants in the new world. As *morue* or *baccalà* or *stoccafisso*, preserved cod is the soul food of the semitropics.

Once you have eaten properly soaked, softened, and desalted fillets of this throwback to the preelectric age, you will understand its popularity. The flaky texture is as alive and appealing as that of the freshest fish, but the flavor has evolved a full-fledged personality. This is why markets in Venice sell presoaked *baccalà*, why, in the winding old streets of the Roman ghetto, deep-fried *filetti di baccalà* are the major local delicacy, and why almost any Italian-language cookbook has several salt cod recipes.

Cod fishing from a dory — *Fishing Gazette*, Mystic Seaport, Inc.

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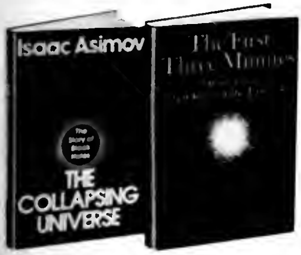

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Portuguese also dote on this unprepossessingly old-fashioned convenience food and have invented several dozen recipes for it, which have been transplanted to Brazil, where *bacalhao* is a staple in the national cuisine. Even in the French West Indies, *morue*, according to André Nègre, the most literate of Caribbean gastronomes, is "one of the basic foods. . . . The Antilles have surrendered themselves to the cod just as Europe in the fifteenth century made itself the vassal of the herring." In his elegant little book, *Les Antilles et la Guyane à travers leur cuisine*, Nègre lists twelve recipes for salt cod, from crude barbecues to delicate little dumplings called *acras*.

In this country, salt cod is still a neglected resource, but not difficult to find. I once even located some in a supermarket in Oneonta, New York. But the major obstacle to its widespread acceptance is, I suspect, its repulsive appearance in stores. Either it appears as colorless, salt-encrusted fillets or as flat, whole, mummylike sheets. It takes a truly heroic leap of the gustatory imagination to believe, as we must, that these embalmed ichthyoids can be resurrected into the sublime emulsified purée, *brandade de morue*, which Paula Wolfert snitched from a neighbor's plate at the Oustau de Baumanière near Arles. At that temple of Provençal cookery, they served up their *brandade* on puff pastry.

With or without such refinement of presentation, preserved cod is certainly worth incorporating into your diet. It is cheap, full of protein, easy to fix, and will bring a new taste to your table.


Grand Banks codfish

Success with it lies almost entirely in the soaking.

I am assuming that you are not going to find already soaked *baccalà* at your corner superette. When you do buy some, therefore, it is necessary to find out which of the two basic varieties of preserved cod it is. Salted cod needs a day or so of soaking in frequent changes of plentiful cold water. It will swell. The salt will wash out. But you can never be sure it is ready to parboil or fry unless you taste a piece of it when it is still raw, in the soaking liquid. It helps to ask the person who sells it to you what he does. Times for soaking vary by as much as a day or two, depending on how extreme the salting has been, and also on how sensitive you are to salt. In Rome, where local inhabitants seem to like salt better than any other group I have ever seen, the salinity standard is quite different from what you and yours are likely to enjoy.

You will want to be even more careful with stockfish (*stoccafisso*), the Rolls Royce of preserved cod, which is dried on sticks in Norway. In Nice, where stockfish is at the heart of traditional cookery, they recommend soaking stockfish for two days in a running stream before using it for the dried cod and vegetable stew called *estockaficada*. The powerful taste is apparently worth the trouble. In her book on Niçois food, *The Cuisine of the Sun*, Mireille Johnston mentions a gastronomic club that meets once a month in Nice to test new versions of *estockaficada*.

Johnston, herself a Niçoise, prefers stockfish to regular salt cod, but she suggests that if you cannot find real

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stockfish, there is a good Chinese approximation, called *tai tze*, sold in eight-ounce packages of such good keeping quality that you can buy them in quantity, happy in the knowledge that should you pass on prematurely, your heirs will find an edible legacy in excellent condition in your larder.

Such considerations may have helped to promote the original, medieval trade in stockfish. But very old cod requires an extreme effort before it can be eaten. A fourteenth-century merchant, quoted by Reay Tannahill in *Food in History*, advised beating ten- to twelve-year-old stockfish with mallets to soften it up before soaking. In those days, preserved cod was so crucial to the European diet that people put up with such laborious preparation. The demand for cod was so great, even on the shores of the fish-filled Mediterranean, that it was a mainstay of trade between Italy and England in the sixteenth century. Stuck with abundant, cheap supplies of seemingly monotonous preserved fish, cooks responded with remarkable ingenuity, inventing out of whole cod a minicuisine.

The simplest method is brilliantly pure. In country after country, peasants hit on the same fast-food solution. Caught with nothing to cook except unsoaked cod, they broiled it directly over the coals of a wood fire; a procedure still popular in some places. Since only the superficial salt is brushed away, barbecued, unsoaked *baccalà* must be a very salty treat.

Less halophilic palates will respond more readily to deep-fried fillets in the Roman style, a dish that supports whole restaurants in the Eternal City and for which enthusiasts of all ages and classes will line up in the rain.

More complex culinary efforts with salt cod usually begin with soaking and then proceed to a further preliminary poaching stage. The cod should be set in cold water to cover, then heated until the water barely trembles. (Boiling will break up the structure of the fish.) After a minimum of seven to ten minutes, sometimes as much as twenty, the salt cod is tender enough to flake easily. Then it can be combined with a whole range of sauces, from béchamel to the broth used normally for bouillabaisse.

Italy has probably gone further in exploring salt cod than any other country. And now that there is a sudden and welcome wave of accurate regional cookbooks being published there for the first time, it is possible at

last to discover some of the myriad approaches to *baccalà* that home cooks have worked out over the years. It is used in scads of variously seasoned stews, with artful mixtures of herbs and spices and sweet-and-sour sauces. Perhaps the most exotic combination of ingredients was hit upon in southern Italy, a one-pot dish containing *baccalà*, onions, tomato purée, sliced potatoes, green olives, pine nuts, grapes, and pears.

On the fashionable Ligurian littoral, fishermen content themselves with less elaborate, but equally delicious, cold fried salt cod marinated in a highly seasoned sauce (*sofrito*) made aromatic with rosemary and garlic—a snack that links centuries and continents.

Marinated Salt Cod, Fisherman's Style
(adapted from a recipe in *La Cucina di Versiglia e Garfagnana*, by Mariu Salvatori di Zuliani)

2 pounds salt cod
1 cup flour, approximately
2 cups olive oil
2 tablespoons dried rosemary
1 tablespoon minced garlic
½ cup vinegar

1. Soak the cod in cold water for one or two days, changing the water frequently. Taste a bit of raw fish to see if enough of the salt has been leached out. When the fish is sufficiently soaked, bone it and remove skin and fins, if necessary.
2. Cut the cod into two-inch-square pieces.
3. Dredge the cod pieces in flour. Shake off excess flour and fry in very hot (375°F) oil until golden brown. The oil should be so hot it smokes, and it should be deep enough in the skillet so that it covers or almost covers the cod. Fry only a half dozen or so pieces at a time in a 10-inch skillet.
4. Drain the finished pieces on paper towel. Set aside in a serving bowl.
5. In the same oil you used to fry the cod, sauté the rosemary and garlic. Brown lightly, then add the vinegar and boil for 3 to 4 minutes. Pour immediately over the cod.
6. Let the dish cool. It is served at room temperature. And it will keep for several days in the refrigerator.

Yield: 4 servings

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

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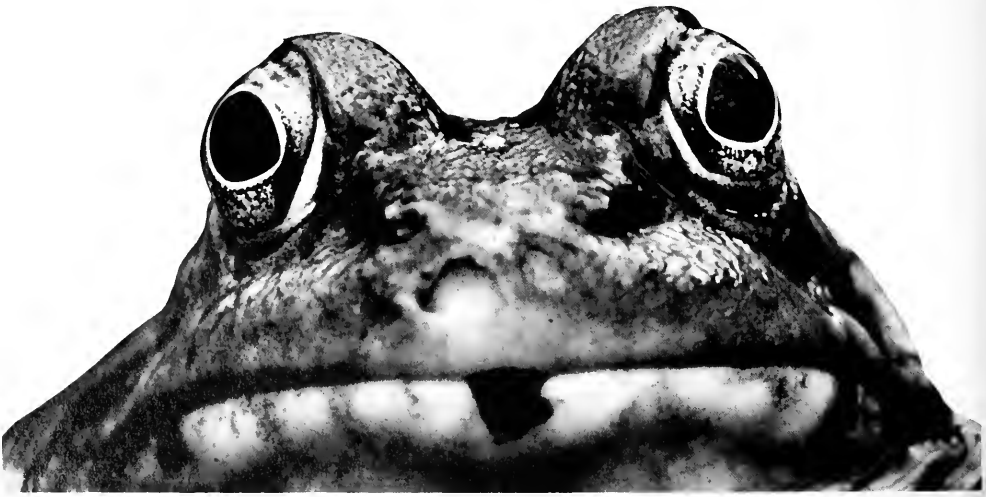

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Plants in Heat

In spring snow, skunk cabbages are warm islands where seeds form and some creatures spawn early

by Roger M. Knutson

In 1672, John Josselyn, Gent., in a book of "New England Rarities," natural phenomena he claimed to have discovered, offered probably the first written description—a somewhat inadequate one—of the skunk cabbage, or skunkweed (*Symplocarpus foetidus*), of eastern North America.

> This plant is one of the first that springs up, after white hellebore, in the like wet and black grounds, commonly by hellebore; with a sheath, or hood, like dragons; but the pestle is of another shape; that is, having a round purple ball on the top of it, beset (as it were) with burs. . . . The whole plant sents [*sic*] as strong as a fox. It continues till August.

Skunk cabbage is so common over most of its geographical range that some of its fascinating but less obvious characteristics might be overlooked today as they were 300 years ago by Gentleman Josselyn. A plant that produces flowers that melt their way through early spring snow and ice, that maintains its flower temperature at a nearly constant 72°F—as much as sixty-three degrees higher than surrounding soil and air—that annually pulls itself deeper into the ground by contracting its roots, and that provides centrally heated housing for several sorts of small creatures deserves more than a reputation for a bad smell.

Eastern skunk cabbage is one of a few temperate-zone representatives of a large family of plants, the Araceae, or aroids. Only eight aroid genera occur in the United States; five are represented by a single species. Some of the mostly tropical relatives of *Symplocarpus* may help reveal the source of some of its unique properties. The aroids include arums, caladiums, callas, dieffenbachias, philodendrons, anthuriums, and other, mostly tropical house and garden plants. In the leaf, stem, and root cells of all aroids, sharply pointed microscopic crystals of calcium oxalate give most parts of the plants an extremely peppery taste and will inflame the mouth tissues of any hapless animal that chews the plants. Even if boiled in several changes of water, skunk cabbage leaves may bite the tongue that eats them. *Dieffenbachia* is sometimes called dumb cane because it can temporarily reduce or eliminate speech in anyone unfortunte enough to chew some of the fresh plant.

Another uncommon feature of all members of the family Araceae is an unusual flower structure, or more precisely, an inflorescence. The short, thick stem that bears the flowers is called the spadix. The spadix is usually large and complex, but it may be a simple ball of tightly packed fleshy flowers, the pestle that Josselyn referred to. The whole flower cluster, as well as the flowerless appendage present in some aroids, is at least partly surrounded by a leaflike spathe, often deeply colored and attractive to potential pollinators. Both spathe and spadix tend to be yellow or brownish purple, like plants pollinated by carrion flies or beetles. Some tropical aroids have massive spathes and spadices. An early twentieth-century photograph of an aging Hugo de Vries shows the Dutch botanist-geneticist overshadowed by the spathe and spadix of *Amorphophallus titanum*, a Sumatran plant, whose inflorescence approaches six feet in height and three feet in width.

Lamarck seems to have been the first to report, in 1778, that during flowering, the spadix of some aroids produced detectable amounts of heat, much like the elevated temperature that accompanies a mammal's estrous period. In blooming *Arum italicum* and *A. maculatum*, Lamarck found heat production was centered in the sterile appendage, reportedly thirteen to eighteen degrees warmer than the surrounding air. Josselyn, who may have only observed plants collected by others, did not notice that the flowering skunk cabbage also produces heat.

By 1822, Nicolas de Saussure, a Swiss botanist best known for his research on photosynthesis, linked the heat production in the spadix of *A. italicum* with a rapid rate of oxygen absorption. Living tissue uses oxygen in the process of respiration, and Saussure had measured a high rate of respiration in the *Arum* spadix during flowering. All living organisms, plant and animal, respire and produce some heat, but very few plants or parts of plants respire rapidly enough or are large enough to be measurably warmer than their surroundings. Interestingly, more recent investigations of the

In early spring, the skunk cabbage's only visible part is the purple green spathe, and as soon as it appears, the spadix inside begins to heat, melting surrounding snow and ice.

L West

Later in spring, after skunk cabbage has completed its flowering and attendant heating process, its huge leaves, initially rolled-up cigar shapes, begin to unfurl.

Harold V Green

biochemical details of respiration in a number of aroids, including skunk cabbage, have shown that cyanide, carbon monoxide, and several other substances poisonous to most oxygen-using organisms have little or no effect on the very rapid respiration of aroids.

While a few aroids do not seem to heat up at all, most do have a short period of rapid respiration and heat production centered in the spadix. Where present, the heating is coincident with maturation of the plant's pollen and egg cells. Some aroids time pollination activity with considerable precision by producing volatile chemicals that are pumped into the environment by the pulse of heat generation. Many aroids seem to be olfactory mimics of excreta or decaying flesh, producing odoriferous volatile chemicals with names such as skatole or cadaverine. These powerful scents advertise the enclosed spaces inside the spathe and lure potential pollinators with promises of warmth, food, and places to lay eggs.

Residents and temporary tenants in various aroids include the so-called arum frog, which lives in the spathe of the South African pig lily (*Zantedeschia*) and feeds on the frequent insect visitors or on spiders that also wait for insect prey. Creatures that look for food or warmth in the complicated spathe of a heated *Arum* flower may well find themselves forced to stay longer than they had planned or even providing food for predatory residents. To attract pollinating insects, the tropical *Amorphophallus* releases fetid odors and provides specialized dispensable nutritious cells on the surface of the spadix. This food supply may help to assure that insects attracted by odors will remain with the plant long enough to increase chances of effective pollination.

As the few temperate-zone aroids moved out of the tropics into less equable climates, natural selection modified details of their flowering, heating, and animal attraction. For the past seven years, I have followed the life of skunk cabbage in northeast Iowa, at the extreme western limit of the plant's geographical range in North America. (Western skunk cabbage, *Lysichiton americanum*, found in Washington and Oregon, is a quite different plant.) Eastern skunk cabbage's North American distribution corresponds to the eastern deciduous forest, where the plant finds the deep, black, mucky soil it requires. The plant seldom grows alone; in summer, the enormous green leaves of a skunk cabbage patch have a tropical luxuriance. On its northward odyssey, the plant seems to have retained elephant-ear-sized leaves, like those of *Caladium*. Individual plants of *Symplocarpus foetidus* vary remarkably little over their range in North America. Their dark, heavy, marble-sized seeds usually germinate within a few feet of the parent plant. Squirrels or other rodents occasionally store seeds, accounting for local dispersal, but the specific mechanisms of skunk cabbage's long-range dispersal remain something of a mystery. Present populations may be the remains of a much wider ancient distribution. Like many plants native to eastern North America, *Symplocarpus* is also found in Japan and along the eastern edge of the Asian mainland.

I began to study skunk cabbage during a February 1971 visit to the forested edge of a frozen marsh, which was fed by small seeps of water from the limestone and shale layers that outcrop along hillsides in the driftless area of extreme northeast Iowa. Although the temperature was in the twenties, the soil in such places seldom freezes

more than a few inches deep, which may explain why several purple green spathes, or hoods ("like dragons," Josselyn said), protruded through the frozen crust at the wooded edge of the marsh. A melted circle in the snow and ice surrounded each hood. The spathe of the skunk cabbage has some of the color of its tropical relatives, but it is much thicker. Spathe tissue consists almost entirely of small separated air spaces, resembling fine styrofoam, which effectively insulate the spadix. Inside the hood, each spadix was warm to my touch.

The next day, I returned with a thermistor thermometer and made the first of many measurements of the internal temperature of those overheated flowers. I found that heating was most intense during the early stages of blooming, after the stigmas were exposed and receptive but before the pollen was released. For two weeks or more, an individual spadix could maintain a temperature thirty-six to sixty-three degrees above air temperature, an impressive extension of the heating capability of the tropical aroids and the temperate-zone *Arum*, which heat for only a few hours or at most for parts of several consecutive days. Because of the skunk cabbage's extended period of heat production, flowering and seed production have a much earlier start. I found that flowers heated for two weeks or slightly longer and then died when air and soil temperatures stayed below freezing. New spathes continued to emerge well into April, however, and every year some of them were accurately timed to begin seed production as early as possible. Hence, the plants would seem to provide their own tropical climate for early embryo development.

Although the intensity and duration of heating were impressive, my early temperature measurements also revealed that the enclosed and insulated spadices of the skunk cabbage remained at nearly the same temperature regardless of the temperature of surrounding air and soil. On colder days or as the air cools during the night, the spadix should lose heat more rapidly; but since it maintains a constant temperature, it must generate more heat as air temperatures fall. The plants seem to have not only a furnace but a thermostat as well.

As Saussure demonstrated with *A. maculatum*, heating is tied to oxygen use or to the respiration process that uses oxygen. My skunk cabbages seemed to respire more rapidly at low temperatures than at high temperatures, a most unplantlike thing to do. On warm March days, I could measure the rate of oxygen use in the blooming flowers by sealing a small pickle jar—christened the Heinz-Vlasic respirometer—over the spathe and spadix and then monitoring pressure changes inside the jar. I monitored oxygen use with my improvised respirometer exposed to warmish March air, and again with the instrument packed in snow, which lay in unmelted piles under trees at the marsh edge. When the temperature around the spathe dropped from 63° to 45°, the spadix nearly doubled its use of oxygen. Repeated observations on days with different air temperatures provided sound evidence that in this one regard my plants were behaving more like skunks than cabbages.

The absolute rate of oxygen use measured at cooler temperatures was in itself surprising. Generally, among homoiothermal, or warmblooded, animals, the smaller the animal, the faster its rate of respiration. The relationship reflects a relatively simple physical principle: in a smaller animal the ratio of surface area to volume is higher,

L. West

As soon as the spathe emerges aboveground or out of water left by melting snow, it opens in a pointed ellipse, exposing the spadix and drawing pollinators and mating creatures to its warmth

with more surface radiating heat for each unit of volume generating it. The respiration rate of skunk cabbage spadices is approximately that of warm-blooded animals of equivalent weight. If spadices of different weights are compared, smaller ones have a more rapid rate of respiration than larger ones at the same temperature. At air temperatures near freezing, a seemingly inactive skunk cabbage spadix is using oxygen and burning food at a rate nearly equal to that of a small shrew or a hummingbird.

Constant day and night monitoring of air and spadix temperatures showed that skunk cabbage plants have a limited capacity to generate heat. Whenever air temperatures dropped below freezing, a slow process of cooling began, and if air temperatures remained below freezing for more than twenty-four hours, the flowers would often die. As long as air temperature stayed above freezing, the spadix temperature stayed at a nearly constant 72° to 74°.

The spadix's response to sudden, unnatural cooling helps us to understand the mechanism that adjusts the skunk cabbage's rate of respiration. If the whole spathe is packed in snow or crushed ice, the temperature of the spadix drops quickly and continues to fall for almost one hour. It then begins to slowly rise to its former level. The constant response time of one hour strongly suggests that movement of some internal substance controls the rate of respiration. The spathe may communicate the drop in external temperature to the spadix by means of a hormonelike chemical, whose identity and working mechanism are still unclear. The hormonal substances that usually control plant activities have no effect on the rate of heat production in the skunk cabbage.

The tiny island of dependable, near-tropical warmth inside the spathe of the blooming skunk cabbage draws a variety of early spring insects and other invertebrates, but most are probably casual visitors. A few may have more important relationships with the plant, based on its ability to continue heating for many days. Ordinarily, honeybees do not fly well if air temperature is below 65°, but they have been observed visiting skunk cabbage at air temperatures as low as 42°. During their stay in the spathe, the bees seem to accumulate enough energy to reach the next plant or their hive. In March, with air temperatures below 50°, I have watched bees collecting pollen from pussy willow catkins and skunk cabbage at the same location. Temperatures inside spathes in the sun were near 80°. Skunk cabbage may attract bees by scent as well as warmth. Bees do not ordinarily visit flowers having the smells associated with most aroids. But to insects—and to humans—an uninjured skunk cabbage flower has a faintly sweetish smell that gives no hint of the mephitic odor produced by any damaged part of the plant—a scent that one observer described as a mixture of skunk, putrid meat, and garlic.

Spiders are frequently found in skunk cabbage spathes, presumably waiting for visiting insects, but at least one kind of spider may be using the spathes for another purpose. In mid-April on Beaver Island in northern Lake Michigan, where nearly a foot of snow had yet to melt in the shady cedar swamps favored by skunk cabbage, I examined one hundred fifty flowering plants and found forty occupied by one or more individuals of the same species of spider, *Pachygnatha brevis*. One of the so-called long-jawed spiders, this arachnid favors swampy areas, where because of its poor eyesight, it uses

The spathe encloses the yellow or purple spadix, source of the plant's heat. The warmth and the sweetish scent given off by an undamaged spadix attract pollinators, such as bees.

touch to find mates among the roots of semiaquatic vegetation. On Beaver Island, each spider had taken up a clearly visible position on the surface of a spadix. The spiders probably do not spin webs, indeed, no webs were present.

None of the spiders in the spathes had any insects, dead or alive. Four spathes held a pair of spiders, one male and one female. I suspect that in heated skunk cabbage spathes, *P. brevis* find convenient, centrally heated trysting places suitable for conceiving and hatching the next generation earlier than usual in the spring season. Every flower housing one or more spiders was in its earliest stages, having only stigmas exposed and no pollen. I examined an equal number of spadices in later stages of blooming, when the anthers have matured and pollen is being shed. These more mature spadices contained some insects and a few small harvestmen, but not one spider of either sex. If the spiders came to those heated chambers simply in search of prey, they would have found greater rewards later when abundant pollen was available.

The first time I dug a mature skunk cabbage plant from the ground in an attempt to move it indoors for easier control of its environmental temperature, I vowed I would not try again without power equipment. A large plant has a massive subterranean stem that may be a foot long and several inches in diameter. The plant's root is actually a severely shortened stem that annually pushes from six to eight leaves and usually two inflorescences above the ground. The lower end of the stem does not taper to a graceful point like the root of a parsnip, but has a broken to slightly rounded surface that appears to have been ground smooth. The hundreds of pencil-sized roots that extend almost horizontally for a foot or more from the stem have deeply ridged and wrinkled surfaces. These wrinkles and ridges explain the appearance of the lower end of the stem. Each year's roots grow out and down from the upper end of the stem, anchor themselves as firmly as possible in the mucky soil, and shorten in unison, wrinkling their surfaces and pulling the large stem into the ground a distance roughly equal to the stem's annual lengthwise growth. In the stem's forcible downward passage through the abrasive soil, the lower end, the oldest part, is smoothed. Gradually it dies and softens, making the polishing easier. The pebblelike seeds generally germinate on the surface of the soil. But within two or three years, the action of the young plants' contractile roots will pull them well below the surface. The subterranean stem may grow only a few millimeters (⅛ inch) or less per year, and most plants must grow five to seven or more years before they are large enough to produce the first spathe and flowers.

A large, mature skunk cabbage does not arouse the awesome sense of eternity that a giant redwood or ancient juniper inspires, but the skunk cabbage could conceivably be older. Unless their habitat is severely disturbed, individual plants of eastern skunk cabbage could probably live indefinitely. In the elaborate language of J. Marion Shull (*Journal of Heredity*, 1924), "Thus it happens that the skunk cabbage that is seen today growing in unpretentiousness in any bog may possibly outrival the sturdiest of oaks in point of age, may not improbably have occupied that very spot long years before Columbus set foot upon our shores and may continue there a thousand years and more from now if only the fates be kind."

After seven years of study, I see the eastern skunk cabbage as considerably more than the fox-scented plant Josselyn described in 1672. It has taken its tropical heritage northward, converting a mechanism for attracting specific pollinators at a particular time into a means of early blooming. The eastern skunk cabbage, a near tropical plant, has become firmly and centrally placed in the web of the late winter life of North America.

Lapps at Bay

When offered the benefits of modern life, these northerners turned to their traditional culture

by Irwin D. and Marion C. Rinder

Most accounts of race and minority problems are all too easily put in terms of villains and victims. A minority group's concerns about their ethnic identity are viewed as a response to poor treatment. The Lapps of Sweden, who have increasingly pressed for their rights and cultural identity, are an interesting exception.

The lives of the Lapps have improved along with those of the general population of Sweden. Given the benefits of a rich welfare state, most Lapps have difficulty faulting the government, except on particulars. Nevertheless, we have observed the early stage of separatist tendencies and a renaissance of Lapp identity. This probably heralds the emergence of a more politically organized and articulate ethnic consciousness among Swedish Lapps in the future.

Ironically, this rise of ethnic consciousness is being led by Lapps who were previously assimilated into Swedish society. And, contrary to the villains-and-victims thesis, it comes in response to two long-range government programs undertaken with typical Swedish technical and humanitarian

Eivon Carlson Nordkalott Foto

skill. The intent of these programs is to benefit Lapps in particular and the total society as well.

The village of Brändosän is a new community, a model for the government's programs for moving and resettling citizens from the northern to the southern half of the nation. It is also an exemplar of the policy to invest, upgrade, and rationalize reindeer herding, while preserving it as a Lapp monopoly in Sweden. Brändosän's more than one hundred inhabitants live in some thirty snug and sturdy houses. In addition to a few large communal buildings, the town has a number of homes for the elderly, whose very survival would have been problematic in the past.

On a cold January day designated for reindeer slaughter, more than twenty cars, half of them Volvos or Mercedes, fill a parking area outside the slaughter shed. Some belong to visitors and contract butchers, others to Lapp residents.

The slaughter and butchering shed, where the shooting, skinning out, and dismemberment of carcasses is performed, is at the edge of the commu-

nity and adjacent to one of the larger buildings that is used as a warm-up and refreshment facility during this cold work. Farther out from the community there is a large open area enclosed with fencing, where herds of reindeer forage; somewhat smaller penned areas, where animals are sorted by ownership; and a cluster of still smaller pens where animals are segregated for inoculation, ear notching (branding), and eventual slaughter or removal for another year of forage and growth. We saw close to six thousand reindeer; of these, three hundred were being butchered each day for four days, a rate of harvest of 20 percent. This is not the only slaughter of the year: in a good year the yield may go as high as 30 or 35 percent.

Enormous trucks carry away the products of the butchering or carry off the reindeer spared until another day. Although some of the animals arrived here in the traditional manner, herded by a man (traditional in this context now means an individual herdsman although he is on a snowmobile rather than on skis), many arrived here by cattle truck and leave the same way. The final touch of modernity is the helicopter, which assists a herdsman in locating his herds and moving them in. Herdsmen now also use field radios.

This is roundup time, harvesttime, payday—the culmination of long effort. Everywhere there is activity: continual in the butchering operation, sporadic and frenetic in the pens, intermittent around the fringes. Bustling veterinarians and their assistants carry pharmaceuticals toward the pens and meat specimens back for inspection. Occasionally, small groups break off from those working at butchering, testing, herding, or kibitzing to avail themselves of the warmth and refreshments in the adjacent building.

Under the shed, continuous assembly-line action reduces the still-warm carcasses to piles and buckets of naturally quick-frozen meat. Antlers accumulate in a growing mound; these will be exported to the Orient to be prescribed for flagging libidos. One young woman spends her day next to the shed constantly stirring ever replenished buckets of blood. And as is true in almost any place of work, we witness an occupational "hustle." Government capitalization and inspection means government surveillance; nevertheless, an occasional local resident is seen surreptitiously carrying off an odd cut of meat or a long bone favored for its marrow. Twenty-two government stamps and continual record keeping testify to the government's involvement in the butchering.

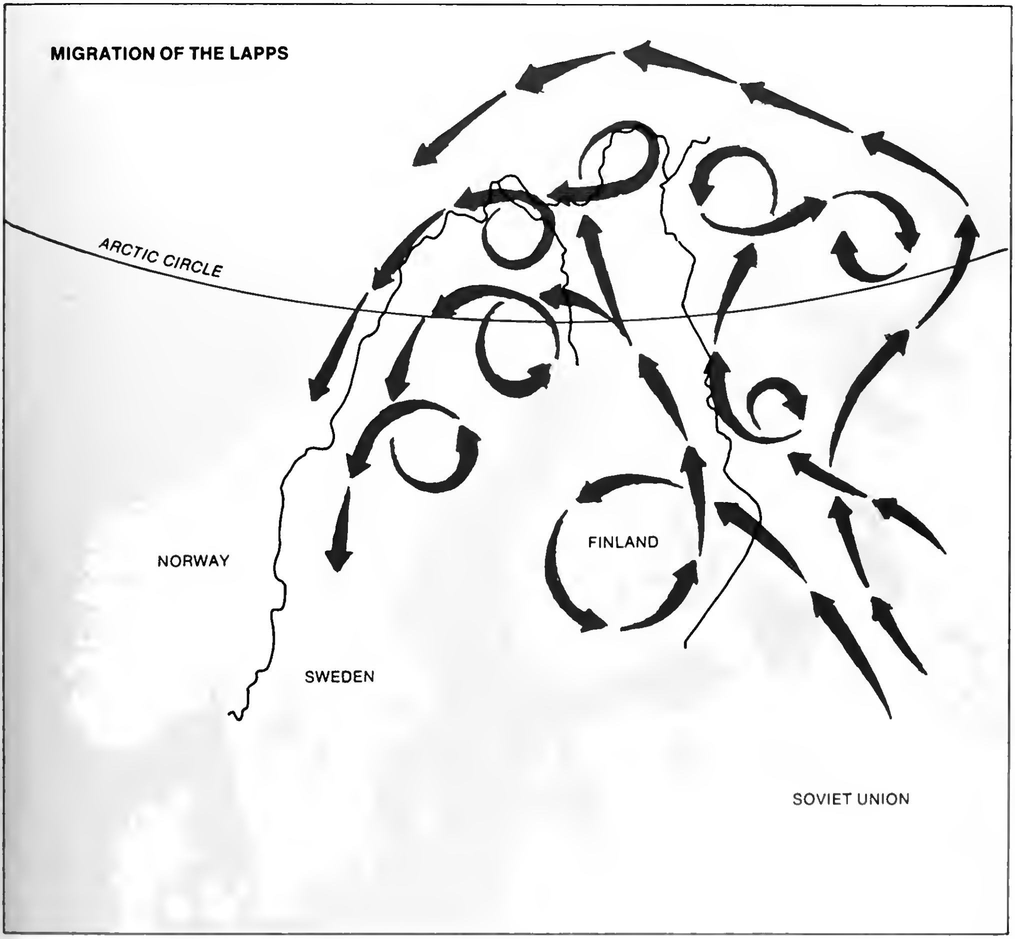
In the roundup and treatment pens (where reindeer are inoculated and ear notched), activities retain some correspondence with traditional Lapp ways. To restrain the deer, young men and women, together with a few older men, lasso and antler-wrestle them to the ground. Other older men and women move outside the pen, laughing, teasing, and shouting encouragement, their high spirits sustained by beverage spirits. When asked about their drinking patterns, one Lapp made an analogy with American cowboys who get to town only occasionally and then with money to burn in their pockets. The analogy seemed particularly apropos, given both the activity and the dress of the participants, a casual mix of some traditional Lapp elements, especially their excellent footwear, and much blue denim and sweaters.

A government agricultural official introduced us to several of the leading local citizens. He is proud of the success of the community, which he had

Please turn to page 55

The traditional Lapp costume, here worn by a child in Norway, is used mainly at festivals and ceremonies. The costume, with its colorful, handwoven bands, varies greatly in different seasons and regions.

George Obremski



Named after its inhabitants, Lapland is a poorly defined region that spans four countries of northern Europe. It stretches westward from the Soviet Union's Kola Peninsula through northern Finland, Finnmark in Norway, northern Sweden, and adjoining parts of Norway, and southward to the Femund Lake area of Norway. The terrain varies from bare mountains and tundra to lake-dotted forests and coastal plains.

Most of Lapland is north of the Arctic Circle, with subzero temperatures for extended periods and months of unbroken darkness in the winter and daylight in the summer.

While estimates vary, there are approximately 20,000 Lapps in Norway, 12,000 in Sweden, and fewer than 3,000 in Finland and 2,000 in the Soviet Union. Although the origin of the Lapps is obscure, most scholars agree that these people migrated from the east in prehistoric times. According to historical documents, the Lapps once occupied land farther south than their present settlements in Finland, but successive migrations of Finno-Ugrians apparently drove them farther north. Lapp scholar Israel Ruong states, "There seems to be no doubt that they are the original inhabitants of Finland."

The Lapps originally were hunters and fishermen. Some evolved into a nomadic life of herding reindeer, a domesticated animal able to tolerate the harsh northern climate. Feeding on slow-growing lichens and mosses, reindeer require extensive pasturage. In the past, the Lapps migrated with their herds. Today few, if any, Lapp families move with the reindeer herds. The animals are tended only sporadically, often by a single Lapp with a snowmobile. Snowmobiles are also used for roundups, and the Lapps even use helicopters to locate reindeer. Many animals are taken to market in trucks.

Reindeer once supplied Lapp families with most of their subsistence needs: food, including milk, clothing, and portage as pack animals. Today reindeer are raised almost solely for market. Fewer than one-fifth of Sweden's Lapps now engage in reindeer breeding, and many of them do other work to supplement their annual incomes. Sweden's present reindeer population is nearly one million.

Reindeer roundup, Sweden

Eivon Carlson Nordkalott Foto

Eivon Carlson Nordkalott-Foto

George Obremski

helped plan; it was the most economically successful of several such efforts. We were informed of, and duly impressed by, the taxable income (public record in Sweden) that some of these community leaders had recently reported. He is also proud of the growing independence and initiative of the residents who increasingly understand how to reach and negotiate with relevant government offices in Stockholm.

Originally Lapps were nomads and moved with herds of reindeer, below. Many Lapps have adopted livelihoods in the forests of the mountains or along the seacoast, left, where they engage in fishing.

The Reindeer Pasturage Law, first enacted in 1928 and revised several times, granted the Lapps a monopoly on reindeer herding. The government has recently embarked on a program of upgrading this traditional mode of Lapp economic support. In addition to planning and capitalizing herding, the government also decided to curtail marginal herdsmen and to forestall the return to herding of those who had left it. Accordingly, no Lapp two generations removed from herding may resume this vocation. Those Lapps still herding strongly support this government position. Although there are other facets of internal differentiation among Lapps, such as dialect, this issue promises to increase political polarization. Nevertheless, the government, rather than other Lapps, bears the greater onus for closing out an option many of Lapp descent would like to feel is always available to them.

The second government program is a large-scale plan to relocate population from the north to the south. The reasons are twofold: to concentrate the thinly settled and widely dispersed population of the north in order to rationalize and economize on the state's distribution of health and educational services, and to remove populations from the path of development of the north's natural resources. Ores, forest products, and water power are important to otherwise resource poor Sweden, and recreational use is increasingly important, as it is in other advanced industrial nations.

These goals, justifiable as they appear and strong as the economic imperatives are, clash with earlier promises made to the Lapps that the northern third of the country would remain their legacy. One early explicit statement of this promise is in the Lappmark Proclamation of 1673. This ancient pledge always seems to lose out when it comes into conflict with opportunities for economic development. Those who remain in the north accumulate grievance after grievance concerning the effects of deforestation, mining, dam, railroad and highway construction, and the adverse impact these have on the [illegible] lands. Others are upset when many of the traditional sacred places [illegible] hills and lakes, are destroyed in the wake of progress.

The Lapps, at least the political ones, characterize themselves as an "invisible minority." They do not mean this in the literal [illegible]

Jan Collsioo, Photoreporters

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DeVos called the Eta of Japan an invisible caste; they are referring instead to the sense of political powerlessness felt by a population of perhaps 12,000 in a nation of 8,000,000. That Sweden has democratic political institutions only enhances that feeling. The government is sensitive to the Lapps as an indigenous minority, and provision is made for consultation with Lapp organizations. In particular, these include organized reindeer herders and makers and sellers of craft products. These two groups receive special attention because they represent the preservation of a traditional culture with viable economic activities. But a majority of the Lapps, who are not engaged in these activities, feel increasingly that their interests are neglected, hence their invisibility. It is the government's position that Lapps not in herding or in crafts (or not living in communities defined as Lappish) are part of the general population and therefore receive no special treatment. The official Swedish census contains no special enumerations for Lapps, although occasional special censuses do attempt to acquire data on Lapps on a voluntary self-report basis. Lapps themselves have taken the initiative, requesting such enumeration beginning with resolutions coming from the 1962 Nordic Lapp Conference.

Another special provision the government makes for the Lapp minority is a Lapp ombudsman, at present a well-regarded Swedish lawyer. His heavy workload consists almost entirely of litigating ancient land claims in various courts. Archaic language in ancient documents must be sifted to clarify the nature of land tenure and ascertain whether the government is currently collecting tax or rent. This is one of the numerous parallels with the life and the sociology of minorities that the Lapps share with another indigenous minority, the American Indian.

The Lapps may appear, at first, to be an "unusual case." But when the dominant segment of a society impinges on an otherwise spontaneously evolving minority identity, the motives and intentions of such action are irrelevant or of secondary importance to those affected. If the actions are perceived as jeopardizing ethnic survival, whether for good or ill, the response will be resentment. Human beings do not want their identities managed for them by others.

Resentment, depending on other circumstances, may take a variety of forms, ranging along a continuum from political mobilization at one end to individual malaise at the other. Perhaps the real paradox of ethnogenesis under benevolent management is not that there is resentment but that it surprises us. □

The reindeer roundup for census and slaughter has some qualities of a western rodeo, including lassoing. Some of the participants wear traditional dress, others jeans. Although some animals are still herded by individual herdsmen, using skis or snowmobiles, many arrive and leave by cattle truck.

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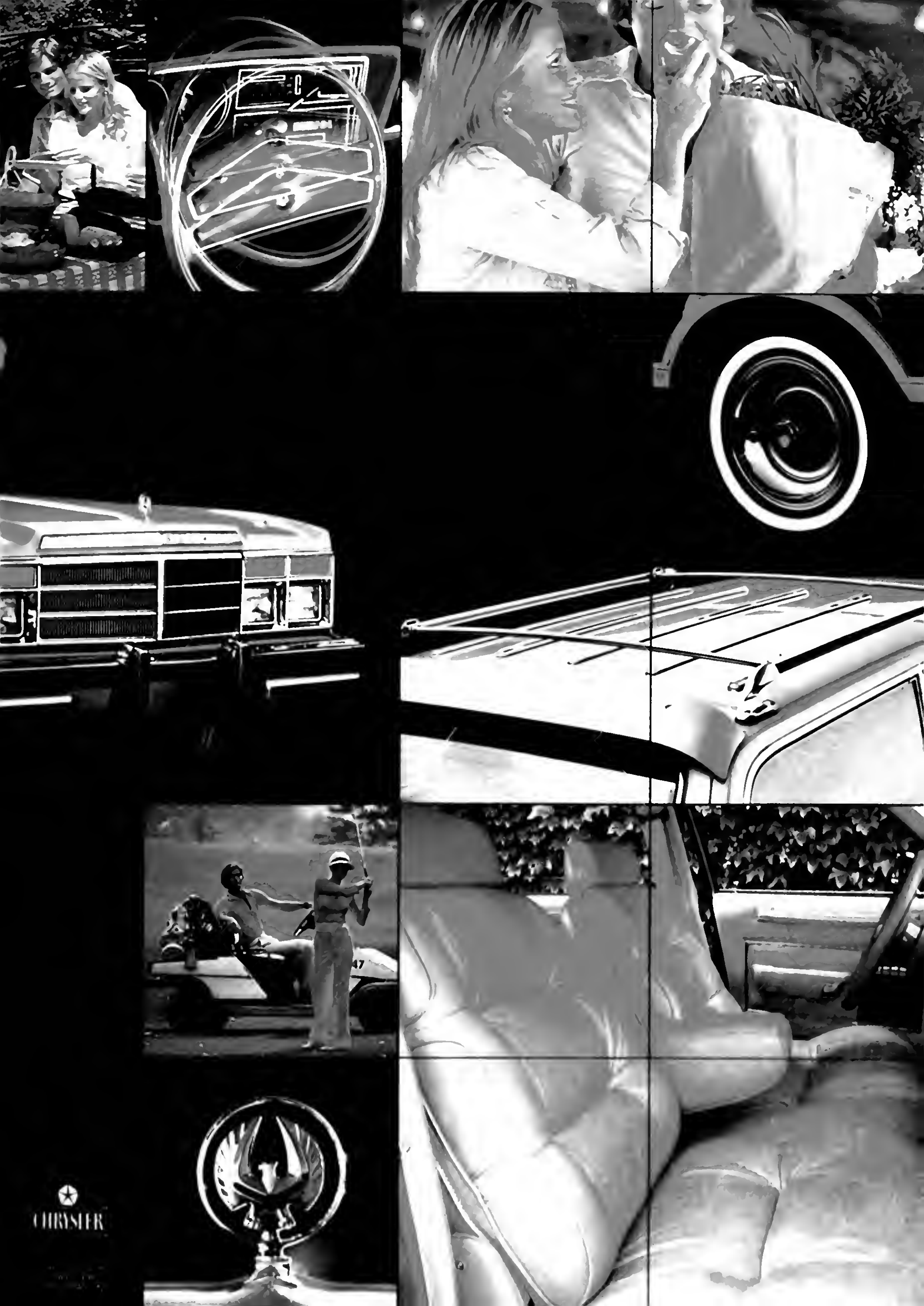

CHRYSLER

Day and Night of the Dolphin

In distinct patterns, the dusky dolphin hunts the elusive anchovy, jumps for "joy," and tries to avoid killer whales

Text and photographs by Bernd and Melany Würsig

With their graceful bodies and faces that seem always to smile, dolphins have a particular appeal. But in the course of evolution, their bodies became streamlined to allow them to move rapidly through the water and their faces became relatively immobile, so that they appear to smile even when they might feel aggressive or threatened. Although as scientists we know all this, we must admit that we, too, find dolphins charming and beautiful creatures. Nevertheless, we have attempted to get away from the too often anthropomorphic descriptions of dolphins by studying them while they are behaving naturally in the freedom of their environment.

Dolphins are related to the toothed whales and are distant cousins of the baleen whales. Of the more than thirty species of dolphins living in the major seas of the world, only the bottlenose dolphin of aquarium and television fame has been studied in great detail.

Traditionally, the lack of study has been due to the difficulties of observing marine mammals in the open ocean. Even in good weather, a large boat will have difficulty staying with a group of dolphins for long. And ship time is also very expensive. At those few times when dolphins can be observed from a boat for several hours, the animals are only seen when they surface to breathe, and their social and environmental interactions go unnoticed beneath the waves. And even then, the breathing pattern and general appearance and shape of their school structure may, because of the boat's proximity, be different from their usual behavior.

Because many dolphin species come within sight of land, investigators have recently begun to observe them from cliffs lining the shore and, above and below the water surface, from small boats, which are less likely to disturb their natural behavior patterns than oceangoing vessels. For several years, we gathered data on the behavior and ecology of dusky dolphins (*Lagenorhynchus obscurus*). We worked at a research station set up by Roger Payne and the New York Zoological Society at Golfo San Jose off the coast of Patagonia, southern Argentina.

Dusky dolphins are about five feet long. They usually travel in small groups numbering six to fifteen individuals and have been seen off the coasts of South America, South Africa, and New Zealand. Although they sometimes travel far offshore, these dolphins often feed on nearshore schools of fish and spend much of their

time within three miles of the coastline. As with other dolphin species, groups of dusky dolphins tend to travel together. As many as twenty to thirty small groups can be found in an area six to nine miles in diameter. Spotting only one group is unlikely; many groups—up to 400 animals—are usually seen in the same general vicinity. This simple observation, apparent to even the casual observer, poses many intriguing questions. Is the large overall group the stable mating unit or the population? Are the small groups themselves stable, perhaps family parties, or does membership fluctuate as individuals cross from group to group? Is there visual or acoustic communication between small groups? What is the social organization of groups and how does it help the animals feed, avoid predators, and reproduce? The questions are almost endless. We have attempted to answer as many as possible by looking systematically at the movement patterns, group composition, and social behavior of these marine mammals.

Dusky dolphins frequented the southeastern section of Golfo San José during the entire year. In spring and early summer, however, they visited this area about three times as often as in fall and winter. The cycle of occurrence was in synchrony with the movements of their major food item, the four-inch-long southern anchovy, which is found in deeper offshore waters in late summer and fall, and farther along the coast to the north of Golfo San José in winter. The movements of dolphins appeared closely allied to movements of their prey, yet the movements cannot be termed migration since they were also observed in winter, albeit less often. Individual animals, which we recognized either from natural marks or from small tags placed on them in conjunction with a radio-tagging study, were sighted in both summer and winter. They still traversed the area when southern anchovy were not present but less often. The movements of the anchovy, on the other hand, were probably governed more directly by water temperature, with the fish migrating north toward the equator in winter.

In summer, dolphins spend much time feeding on anchovy, and we were able to follow the progression of daily events particularly well. At night the animals move in small groups, usually within one and a half miles from shore. Each dolphin stays close to the surface, diving for an average of only six seconds. They move slowly, with a mean speed of three miles per hour. When we approached dolphin schools moving in this manner in early morning, they avoided the boat in "ameboid" fashion, with that part of the school closest to the boat deforming away from it. This kind of schooling, where individuals appear to act as part of one large organism, is frequently seen in fish schools and bird flocks. It suggests that each individual of the group integrates information from the environment in close consort with other group members. It has been described in detail for apparently resting schools of Hawaiian spinner dolphins. We believe that the nighttime low in activity—slow movement, ameboid deformation of groups, and absence of long dives—also signifies resting in dusky dolphins. It makes sense that they would not be feeding on schooling fish at night, for southern anchovy schools disperse during darkness and are then presumably harder to catch.

As the morning proceeds, groups of dolphins "wake up," that is, they begin to move more rapidly than at night, with a mean speed of about four

The killer whale, above, is the major predator of dusky dolphins in South Atlantic waters. In an attempt to escape, a dolphin, left, will swim into shallow water close to the coast.

miles per hour. They travel in more loosely knit groups, and individuals may dart toward a boat in apparent curiosity. As they hunt for fish, they also travel farther from shore and dive for longer periods of time.

Feeding is characterized by a school of fish near or at the surface, dolphins around and underneath the fish, and birds—terns, gulls, albatrosses, petrels, giant petrels, shearwaters, cormorants, jaegers, and others—congregating above. Mainly because of the birds, such an activity can be seen for miles.

Before they feed, dolphins swim through the water on a basically straight course, in sharp contrast to their rambling movements near shore while resting. Usually they spread out in a rank perpendicular to their line of movement, with about 65 to 135 feet separating each animal. Presumably, this formation allows the dolphins to scan a larger swath of sea as they use their remarkable sonar abilities to echolocate for schools of fish. Once they locate a school, dolphins dive for longer periods and spread out in the school's general vicinity. Apparently they are driving the fish toward the surface of the water, using the surface as a wall through which their prey cannot escape. This "herding" has never been observed in fine detail, but three to ten minutes after the dolphins stop and mill, a school of fish almost invariably appears at the surface.

Terns flying in the vicinity begin feeding on the school, followed by gulls and other, slower birds. After ten minutes of such activity, there may be more than a thousand birds in the area, all attempting to get a share of the herded prey. The birds seem to be taking advantage of the dolphins' herding without giving anything in return, but the story may be more complex.

We mentioned earlier that many small dolphin groups are found in the same general area, often separated from each other by no more than a third of a mile. But when independent groups move rapidly, apparently in search of food, they may be separated by as much as five to six miles. When one group begins feeding, other groups quickly converge on the feeding activity. How do they learn of distant feeding activity? Over relatively short distances, underwater sound may be a cue. Dolphin sounds can travel up to at least a few miles, and the type of vocalization occurring during feeding may reach to nearby groups. But when the activity is many miles away, we believe that sound is probably not involved. Yet we have measured dolphins moving rapidly in a straight line toward a feeding activity from as far as five miles. At these times, individual animals of the advancing group may jump as high as sixteen feet out of the water in high forward leaps. These leaps become progressively lower and finally subside altogether as the animals near the feeding activity. We suggest that the distant dolphins are cuing in on the activity occurring above the water surface, mainly the flying and hovering birds; thus the birds have become an unwitting but vital source of communication to the dolphins.

This is, however, only a hypothesis. We do not know at present whether dolphins' in-air eyesight is acute enough to make use of such long-distance information. And even if it is possible, we do not know how important it is for other groups to spot feeding activity from far off. Yet it is intriguing to think that as the birds evolved to take advantage of the herding efforts of the dolphins, the dolphins evolved or perhaps learned to take information from the birds' behavior.

When groups coalesce to feed, feeding activity lasts longer than when they remain separate. Translated into actual feeding time, this means that when only about ten dolphins are involved, the average feeding is six minutes, but when more than fifty dolphins feed, the average time is twenty-six minutes. The number of birds also increases with length of feeding, as more and more birds join the action from distant

perch sites on shore. Why does feeding last longer when more dolphins are present? Many reasons, not mutually exclusive, are possible. Thus, when few fish are present this may be communicated in some way to nearby groups, and they do not "bother" to join. Alternatively, many dolphins may prolong a feeding activity because they are able to herd greater numbers of fish into a tight area, so that individual dolphins can then feed more efficiently. What we don't know—and what is really the important question—is whether there is some critical number of dolphins at which the dolphin "surround net" is most efficient, that is, most productive of food to the individual dolphin. We believe that this hypothesis fits, at least at times. If so, we expect that some communication mechanism has evolved enabling dolphins to "tell" nearby groups that feeding is in progress.

A likely candidate for such communication is leaping. In oceanariums dolphins are trained to leap on command, and in the freedom of the ocean, they leap in many different ways. Although leaps have been described for a variety of species, we believe that we may be the first to have seen a particular progression of leap types as related to feeding. Before feeding, we saw mainly headfirst reentry leaps. That is, the dolphins leap out of the water headfirst, arch their bodies in midair, and reenter the water headfirst. These leaps cause little or no water splash, are relatively noiseless, and appear to allow dolphins to come out of depth, breathe rapidly, and descend to depth again. They occur in the initial phases of apparent herding of fish, when dolphins spend much time somewhere below the surface. When the fish school is driven to the surface, there is a transition to "noisy" leaps. These are characterized by a dolphin's headfirst exit from the water, and a falling back into the water on its side, back, or belly. In many instances, the dolphin arches its body so that it reenters in the form of an inverted U, much as we might cup our hands to create the loudest possible splash when striking the water. Dolphins' splashes are so loud that they can be heard for some distance both above and below water. These leaps occur all around the fish school and may serve to herd or "net" the prey into a tight area. Since they can certainly be heard by nearby dolphin groups, such noisy leaps may serve to tell these groups that feeding is in progress. If our hypothesis of visual communication over longer distances should prove correct, dolphin groups orient not only toward flying birds but also toward the leaping dolphins.

Using the water surface as a "wall," dusky dolphins drive southern anchovies into a tight school. The more dolphins involved in the herding, the more efficient the operation seems to be.

Jumping high out of the water may enable dolphins to spot the clouds of swirling sea birds that invariably appear over a group of feeding dolphins. Such activity can be seen for miles.

As feeding ends, a third leap type becomes dominant. This has been termed the acrobatic leap, for it involves spins around the longitudinal axis, single and double backflips (or somersaults), and all variations of these basic leap types. The dolphins appear to be performing, and it is difficult to imagine that they do so for any reason other than "pure joy." Actually, this may not be far from the truth. After feeding, one of the basic necessities of life, many mammals play (although it is also true that at such times, many predators sleep or at least rest in some manner). A more scientific explanation might be that such leaping is an adjunct to social activity and to establishing and reaffirming social and sexual bonds. Acrobatic leaps may be a type of social facilitation, with an attendant "call" for social and sexual activity. At precisely this time we see much belly-to-belly swimming and apparent copulation, but whether this is purely sex or perhaps part of bond strengthening and nonsexual social communication, we do not know. As an apparent outgrowth of their "exuberance" after feeding, dolphins also associate readily with sea lions, elephant seals, right whales, boats, and kelp for hours on end. They appear to be playing, with play defined as an activity that has no obvious reward but its own enjoyment.

Because feeding begins in the morn-

ing and continues to midafternoon, the most exuberant behavior is also seen in the afternoon. All this occurs mainly in spring and summer, however; in the winter very little feeding on southern anchovies occurs. And in the winter, a reversal of day–night activity may take place; that is, in summer dolphins appear to rest at night and feed during the day, while in winter they appear to rest in the day and, although we have no direct proof for this, feed at night. Our reasons are as follows. In winter, tight, small groups of dolphins move slowly nearshore throughout the day and dive for only brief periods. At night, however, their dives are longer, just as in summer feeding activity. Perhaps dolphins feed near the bottom or on other fish during winter nights, but we can only guess at what is actually going on.

One thing is certain. While resting, whether in the daytime in winter or at night in summer, dolphins are more often found in shallow nearshore waters than while feeding. The major predator of dusky dolphins is the killer whale, and on the few occasions that we saw killer whales attacking dolphin groups, the smaller marine mammals fled toward the shoreline in an apparent attempt to avoid the larger predators. It thus appears likely that dolphins may rest close to shore at least in part to avoid killer whales. Near shore they can receive no nasty surprises from below or from the flanking shoreline, and when killer whales come from the open ocean the dolphins can presumably escape more easily in shallow water, where the larger predators cannot maneuver as well. A similar hypothesis has been put forward by biologists Kenneth S. Norris and Thomas P. Dohl for Hawaiian spinner dolphins resting close to shore to avoid or minimize the attacks of deepwater sharks. If true, these hypotheses present not only food availability but also predator avoidance as the two major determinants of group movements.

There is another important question regarding dolphin natural history: What is the social organization of these animals? The answer is that we do not really know. They are sexually monomorphic, that is, both male and female look very much alike to us. Their appearance and the fact that males and females are found in about equal numbers in small groups—which we discovered by catching animals to determine their sex—argues against a harem-type system in which one adult male, usually larger than other group members, mates with several females. Many dolphin species in captivity seem to have preferred sexual partners but will mate with other animals as well. We suspect that mating may be somewhat promiscuous in the wild also. Since most mating appears to take

Hovering, diving, and floating terns, gulls, petrels, cormorants, and shearwaters mark the spot where dusky dolphins have herded fish into a circle. Birds and dolphins may cue in on each other

After feeding, dusky dolphins perform a series of acrobatic leaps. These are either "play" or some type of social facilitation. Belly-to-belly swimming and copulation often follow.

place after the animals have fed and when many small groups have combined into a large after-feeding supergroup, intergroup matings may be common, and the entire supergroup of 300 to 400 animals may constitute the mating population.

Studies on Indo-Pacific humpback dolphins, Hawaiian spinner dolphins, Florida bottlenose dolphins, and South Atlantic bottlenose dolphins have shown that the group structure of these coastal animals is highly variable. At least some individuals consistently move from group to group, with no apparent home group to call their own. Often, however, small parts of groups consistently stay together even when moving from group to group. Various scientists have suggested that such

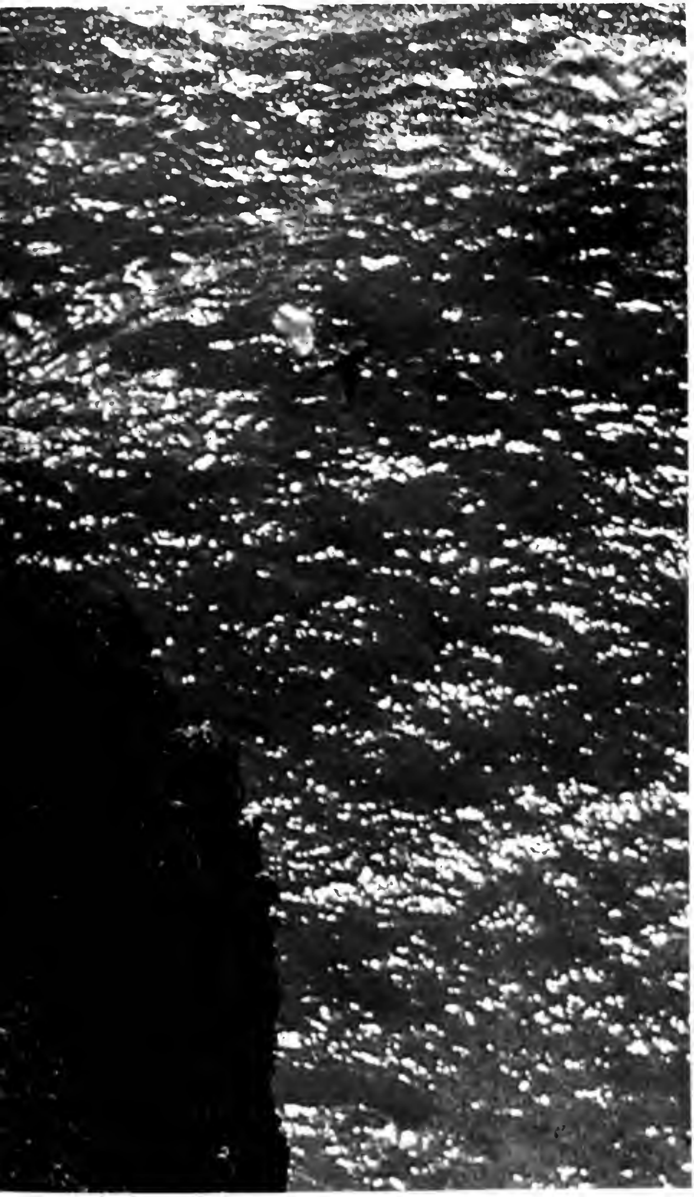
fluctuation of group composition may be a response to changing food availability, with smaller groups forming when food is scarce and larger groups when food has been found or is more abundant. A similar organization also occurs in the social system of African chimpanzees and possibly in various species of South American spider monkeys.

We see this kind of variability in different species, and we have seen evidence for it in dusky dolphins. When we observed known individuals in small groups aggregating with other small groups during and after feeding, the same individuals segregated into their previous small groups upon group separation. This has only been observed four times, however, and group stability has only been followed for up to seven days—simply because it is extremely difficult to go up to the same groups repeatedly and identify individual animals. This kind of identification is possible, however, with long and diligent efforts, and we hope that in the future we will learn more about the social systems of dusky dolphins and other marine mammals. □

Monopoly Games Sea Birds Play

Every spring on the precipitous cliffs of Prince Leopold Island, gulls, murres, fulmars, kittiwakes, and guillemots claim their own neighborhoods and offshore fishing grounds

Text and photographs by Fred Bruemmer



In late July 1819, William Edward Parry, commanding H.M.S.'s *Hecla* and *Griper*, sailed into Lancaster Sound in search of that Holy Grail of arctic exploration, the Northwest Passage. He was amazed by the wildlife wealth of the region.

"Greenland swallows" (arctic terns) flew gracefully above his ships. "Sea horses" (walruses) lay "huddled together, like pigs" on the ice and were "stupidly tame." Polar bears ambled across the floes. The sailors lassoed one and killed it with boarding lances. White whales "were swimming about the ships in great numbers." Narwhal were "very numerous." On August 1, they saw eighty-two bowhead whales.

On August 3, as he sailed west from Lancaster Sound into Barrow Strait, Parry spotted a small, stratified, sheer-cliffed island and named it "in honour of His Royal Highness Prince Leopold of Saxe Coburg." Heavy ice prevented a close approach. Prince Leopold Island had been seen and named—and was promptly forgotten. One hundred thirty-nine years later, in the late summer of 1958, Thomas W. Barry of the Canadian Wildlife Service flew over the small island and discovered that it was home to one of Canada's largest and most diverse sea bird colonies.

For the past few years, the island's bird colonies have been intensively studied by a team of scientists and technicians led by David Nettleship of the Canadian Wildlife Service. (This article is based on their observations and data.) Their work has assumed a special urgency since this region, one of the richest marine wildlife areas in Canada, is also the focus of industrial exploration. Vast deposits of natural gas have already been discovered, to be taken south eventually by pipeline or, in liquefied form, by giant tankers. Offshore oil exploration is planned. Prince Leopold Island itself is easy to protect. But as Nettleship has pointed out, "the protection of feeding areas is as essential and vital and may be much more difficult to ensure."

Prince Leopold Island is eight mile

The cliffs of Prince Leopold Island soar to a height of 1,200 feet. Glaucous gulls nest at the highest elevations, followed, in descending order, by fulmars, murres, kittiwakes, and black guillemots.

long and five miles wide. On its eastern side the grayish brown limestone cliffs soar up from the sea to a height of 1,200 feet. The cliffs around the rest of the island are lower and in most places banked by steep slopes of frost-shattered rock debris. Two flat spits jut out from the island: one, short and broad, toward the north; the other, long and curved, toward the south. Weathered, lichen-encrusted whale bones lie on both spits, remnants of prehistoric Eskimo dwellings. Near the island, powerful currents converge and masses of mineral-rich, upwelling water, here and in the adjacent sounds, straits, and inlets, form the basis of the immense marine life of this region.

Five sea bird species share the island cliffs in orderly sequence. Glaucous gulls nest at the top and near the very edge of the island. Just below them, fulmars nest on ledges and in niches, in a broad belt extending virtually around the entire island. Beneath them, about 192,000 thick-billed murres brood their eggs on narrow ledges or atop weathered stacks. On the even narrower ledges below and on tiny cornices, the black-legged kittiwakes nest. And in clefts and fissures from the middle to the bottom of the cliffs, black guillemots raise their young.

Just as these five species share the vertical space of the island cliffs, each using a slightly different habitat, so do they exploit the surrounding sea in noncompetitive fashion. The glaucous gulls are the island's resident robbers and scavengers. The fulmars seek their chiefly planktonic food far from the island, as much as two hundred miles away, and feed at the surface of the sea. The murres rarely fly more than seventy miles from the island and dive for the fish that form their principal food, often to a depth of several fathoms. The kittiwakes usually fly twenty to fifty miles from the island and catch their food at or near the surface. The black guillemots prefer benthic food and hunt for it primarily in the shallow littoral zone near the island.

In this city of birds, the glaucous gulls are ever vigilant for easy pickings. They are large, white birds, with pale gray mantles, bright yellow eyes, and powerful beaks. Nineteenth-century sailors called them "burgomasters" because they are so big and bossy. On Prince Leopold Island, there are two distinct populations of glaucous gulls. One, living at the top of the island, consists of widely spaced pairs, which build their big moss and grass nests, occupied year after year, near the tips of jutting headlands or atop rock stacks. Each pair is fiercely territorial and looks upon the section of murre colony directly below its home as its private larder, which it defends against other, trespassing glaucous gulls. These top-of-the-island gulls are essentially raiders and marauders. They steal eggs and kill chicks.

The second group is colonial and less predatory. These gulls nest on flattish ground toward the base of the south spit. Their nests are fairly close to each other, and they defend their nesting area as a group. Primarily scavengers, they patrol the island beaches, collect fallen eggs and dead chicks, and put finis to any injured bird they happen to find.

In contrast to the predatory glaucous gulls, the island's other gull species, the kittiwake, is small, graceful, and gregarious. Much of kittiwake behavior is influenced by its cramped and precarious nest sites on the narrowest ledges, cornices, and tiny projections of precipitous cliffs, hundreds of feet above the sea. Nesting space for the 60,000 kittiwakes on Prince Leopold Island is limited and precious; competition, keen.

The kittiwakes arrive at Prince Leopold Island in May. Older, experienced birds reclaim the sites they used in previous seasons. They fly inland in large, screaming flocks, gather mosses and grasses on the snow-free slopes and meadows of the fairly flat-topped island, and build deeply cupped nests, cementing them firmly to rock walls and ledges with excreta.

The courtship ceremonies of other gulls involve a great deal of movement and wing display, but space limitations would make this awkward and risky for the kittiwakes. Instead, each pair sits quietly on its nest site, often for hours. They rub bills, gently preen each other's head and nape, and wail, often in concert, displaying toward each other the bright orange red interior of their mouths. The excitement is infectious. Other kittiwakes begin to clamor, and waves of screaming and wailing ripple through the colonies.

The thick-downed chicks hatch, on average, after twenty-seven days of incubation by both parents. The chicks of other gulls tend to leave the nest soon after they hatch, wandering about or hiding among vegetation and rocks. Kittiwake chicks have nowhere to go and stay on their nests. Later, when they are big and no longer brooded by one of the parents, the chicks (usually two) press themselves close to the rock wall and in a storm anchor themselves firmly to the nest with their sharp-clawed feet.

While one parent stands guard with the chicks, the other forages for food, mainly small crustaceans and fish

Thick-billed murres are the most numerous species on the island. They breed on ledges barely wide enough to hold an egg. The young make their maiden flights by hurtling off the ledges.

caught within a radius of up to fifty miles from the island. On their return, the kittiwakes follow very definite flight paths toward their colonies. Occasionally they are ambushed. Several pairs of parasitic jaegers—swift, bold pirates—nest on the island. They pursue the homing kittiwakes and, in a dazzling display of aerial skill, chase and harry the birds until they drop or regurgitate their food. The jaegers swoop down and snatch the bits in midair.

The black guillemots occupy the lower stories of this high-rise bird city. They are small, elegant birds: their plumage a velvety black with a deep greenish sheen, the wing patches a flashing white, feet and mouths a vivid scarlet. Compared with the other birds nesting on exposed, storm-lashed ledges, their domestic existence appears secluded and secure. They lay their eggs in crannies and holes beneath the jumble of scree or in the clefts and fissures of limestone chimneys, which rise amidst the talus near the sea.

Each female generally lays two eggs. Incubation begins as soon as the first egg has been laid (the second is usually added two days later), and as a result, chick number two is disadvantaged, a frail latecomer with a very short life expectancy. Soon after the black-downed young are hatched, both parents forage for food and return at fairly frequent intervals with little creatures from the deep: polychaete worms, shrimps, amphipods, and most frequently, a small, eellike ocean pout known as the fish doctor (*Gymnelis viridis*). The moment a food-bearing parent slips into the breeding cleft,

Glaucous gulls (with two chicks, right) are the island's primary predators. The colonies of murres are virtually private larders for the gulls, who regularly take eggs and exposed or injured young.

Not all kittiwakes manage to bring the food they have caught to their chicks. Some are intercepted by parasitic jaegers who chase and harry a kittiwake until it regurgitates its catch.

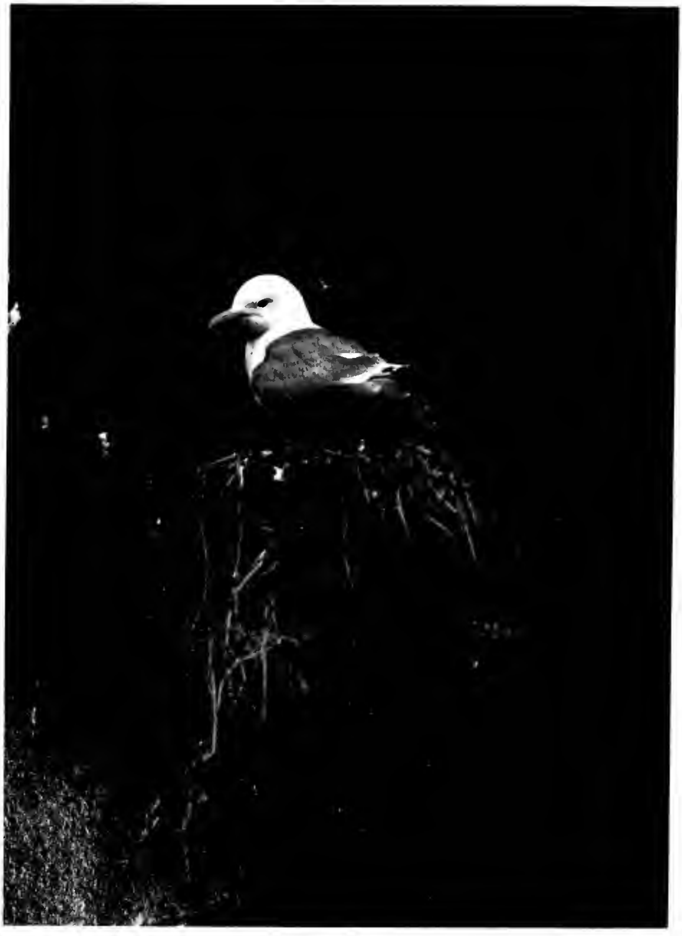
chick number one rushes forward to claim the proffered catch, often trampling its weaker sibling in the constricted space. Nettleship's studies show that less than 20 percent of the weaker chicks survive to fledging age.

While the mature adults are busy raising their chicks, younger black guillemots assemble in small groups on favorite trysting tors. They bow and whistle and flirt. Gaping seductively, they display the scarlet lining of their mouths. And they go on prospecting trips, exploring rents and clefts in the weathered limestone as possible future nesting sites. Occasionally, they venture into occupied holes and one hears the hopeful cheeping of the chicks inside. When one of the parents arrives, there is a furious scuffle, and an instant later the flustered intruder bolts from the hole and flies out to sea.

A murre colony is called a loomery or a bazaar. The latter term seems apt. One murre is a very loud and disputatious bird. In the thousands, they produce a noise that the Canadian biologist Leslie M. Tuck has likened to "the roar of the sea after a storm." It seems a place of utter chaos, but a murre colony is really a well-ordered, harmonious community.

The older, more experienced thick-billed murres arrive first at the breeding ledges; each claims the same small place along the mighty, multitiered cliffs on which it incubated its egg the year before; and it is at this exact spot, the focus of its breeding life, that each murre meets its mate after a separation of about eight months.

According to Nettleship, murres usually first breed at five years of age.



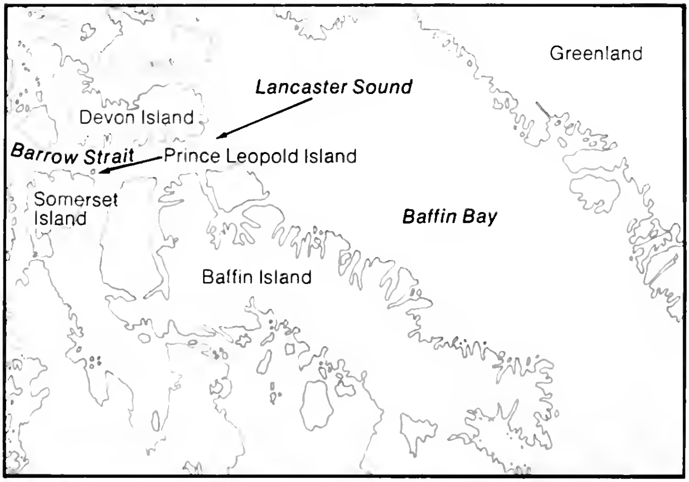
Nesting space for the 60,000 kittiwakes is limited. They fly inland to gather moss and grass and, with mud, construct deeply cupped nests that are cemented to the smallest ledges with excreta.

They tend to return to their natal area; consequently murres in a given area form subgroups within the colony and are genetically closer to nearby murres than to birds in adjacent groups. Their position in the group is probably determined by their relative weight, strength, and competitive ability at the time they first select and hold nesting sites. Nonbreeders (two- to four-year-olds) spend much of their time in "clubs" at the bottom of the cliffs and in nearby waters.

Murres tend to do things en masse. The sight and sound of tens of thousands of closely spaced murres displaying, courting, and screaming is highly stimulating. They work themselves and each other into a crescendo. As a result, most murres mate at about the same time, most eggs are laid in a fairly short time span, and most chicks reach fledging age (about twenty days after hatching) in the same week to ten days in the latter part of August. This breeding synchrony probably has considerable survival value for the murres.

Both parents alternate at incubating the large, pear-shaped egg, and after the chick hatches, they take turns brooding and guarding it, the male usually assuming the "night shift." The foraging mate returns with a fish (usually arctic cod) held lengthwise in its beak, announces its arrival with a loud squawk, settles next to its mate on the narrow ledge, and bows in rapid jerks; the mate responds with similar obeisances. As the neighboring birds squawk, shuffle, and bow, a ripple of heightened noise and movement spreads outward throughout the already noisy colony. The parent with the fish makes a guttural, churring sound. Responding with an insistent, begging cheep, the chick receives the fish and swallows it, headfirst, with convulsive gulps. Often the fish is longer than the chick, which sits there, potbellied and strained, the fish's tail protruding from its mouth. After a while, the chick gulps again, and the fish disappears. Digestion is rapid.

Every twenty-four hours, the parents bring in an average of three fish, weighing a total of 35 grams, and the chicks, which appear to be extremely efficient food converters, gain an average of 15 grams each day. They lose their dense, fluffy natal down and at the age of twenty days look like miniature replicas of their parents, with one important exception. Their primaries are not yet developed and they cannot fly, which is, of course, awkward since they may sit nearly a thousand feet above the sea.



When threatened, a fulmar chick responds by squirting an oil that destroys the insulating capabilities of a bird's feathers. As a result, gulls leave the fat fulmar chicks alone

In the latter part of August, as the time for departure approaches, the excitement in the great murre colonies increases. The volume of noise, already immense, rises to an even more frenetic pitch, the guttural "arrr-arrr-arrr" of the adults mingling with the shrill, strident cheeping of the chicks. If the weather is bad, the chicks defer departure. Then comes a perfect night, gloomy gray but calm, and the chicks leave in droves, most of them between 10:00 P.M. and 1:00 A.M., when gull predation is presumably lowest.

A chick is ready to take the great jump. It shuffles along the ledge, its parent (usually the male since it is night) follows closely. The chick, hundreds of feet above the sea, approaches the edge of the ledge, peers down into the void, and backs off in apparent fright. Undecided, it patters back and forth. Then suddenly, with a special, shrill "launching call," a distinctive cry unlike any other it has ever uttered or will ever utter again, the chick hurtles into space, its tiny, poorly feathered wings beating frantically. It tumbles, flutters, glides. An instant

A black guillemot at the entrance to its nest in a rock cleft on Prince Leopold Island, in Canada's Barrow Strait. Five species of sea birds have divided the sheer cliff into breeding levels.

after the chick jumps, the parent follows, flying slightly behind and to one side of the falling youngster. Ideally, parent and chick land on the sea below nearly simultaneously and close together, and soon after both swim toward the open sea.

But there are many mishaps. If a parent's timing is slightly off, parent and chick may land far apart at sea. Both cry loudly and often they find each other—in a mass of thousands of other calling adults and chicks—but sometimes they do not, and forlornly cheeping chicks, swimming in circles beneath the cliffs, are common. A falling chick may hit a ledge below and bounce off like a fluffy ball, but the flying parent, unable to stop in midair, overshoots and they lose contact. For the chick it is probably the riskiest day of its entire life. About 20 percent of the chicks do not survive. Those that do are usually safe. Since thousands may jump in a single night, even the glaucous gulls and their gluttonous young have more than they can eat just picking up the dead and dying.

When the foraging female murre returns, she finds her mate and chick gone. Seemingly bewildered, she sits on the nest site, holding the limp fish, bobbing and bowing to no one in particular. Eventually she eats the fish. She usually remains at the nest site for another two weeks, defending the small, reddish, excrement-smeared patch of ledge against any would-be usurpers, thus probably fortifying her attachment and claim to this vital bit of rock space.

In the meantime, flotillas of fathers and chicks swim east through Lancaster Sound, then turn southwest toward the coast of Greenland where most will spend the winter. The mates, if they survive, will meet again next May at their tiny private plot along the giant cliffs of Prince Leopold Island.

When the fulmars arrive at the island in late April and early May, many of their breeding ledges are still covered with snow. Undeterred, the birds begin to clean their nest sites, exactly the same spot each pair occupied the previous year. They hack at the snow with their powerful bills and push it away with strong, broad, palmated feet. Two students working with Nettleship, Anne Linton and Erick Greene, saw a pair of fulmars tunnel through nearly five feet of snow to reach their nest site.

Each female lays a single, coarse-textured, chalky white egg, usually in the first two weeks of June, and both parents alternately incubate the egg for forty-seven to forty-nine days.

Fulmars are slow-maturing birds. They do not mate until they are at least six years old, and probably not until they are nine. But long before that, they return to Prince Leopold, to court and coo, to familiarize themselves with potential breeding sites, and perhaps to learn the difficult art of landing on narrow ledges in the vicious updrafts that tear at and buffet arriving birds, especially on stormy days. These immature fulmars spend weeks on end "sweethearting," as British ornithologists call it. They sit in pairs (occasionally trios, but that often leads to disputes), cackle and chuckle at each other, mouths agape, showing the deep purple lining, and languidly weave their heads from side to side or up and down. They gently nibble and bill each other. Pair bonds are formed, and the birds nearing maturity begin to claim future breeding territories. Of the more than 200,000 fulmars on the island, about 40 percent are nonbreeders that are there to find a breeding site, pair, and practice housekeeping.

For ten to twelve days after it hatches, the fulmar chick is brooded by the parents. Then both leave on long foraging trips, sometimes collecting food at a distance of two hundred and more miles from the island, while the fat, fuzzy-downed, squablike chick sits alone and unprotected on the nest site. Yet, except on rare occasions, the rapacious glaucous gulls leave the fulmar chicks alone. They are leery because the chicks have a potentially deadly "weapon" at their disposal: oil.

Fulmars eat a great variety of planktonic crustaceans and, especially during the chick rearing period, take fish, mainly arctic cod. Their main invertebrate food is copepods (*Calanus hyperboreus*), little rice-sized crustaceans, which they pick up individually, jabbing at them industriously while swimming along, rather like chickens pecking grain. Each copepod contains within its body a minute, reddish droplet of oil rich in vitamin A. The fulmar converts most of its food into a stomach oil and concentrates it at the same time. According to New Zealand scientist John Warham and his coworkers, "the production of stomach oil involves a 5- to 35-fold concentration of the energy in the prey at the time of capture."

At the nest site the adult regurgitates this energy-rich oil, which is eagerly imbibed by the chick. Much of it is stored in the chick's proventriculus. When a chick or an adult feels threatened, it ejects this oil—in squirts of evil-smelling liquid—to a distance of two to three feet. (*Fulmar* is a Scandinavian word meaning "foul mew," that is, filthy gull.) This oil mats the feathers of other birds and destroys their insulating quality. Experiments with fulmars, gulls, and other sea birds carried out in aviaries at the Netherlands Institute for Sea Research have shown that "oil from the stomach of a fulmar threatens the life of sea birds in the same way as fuel oil. Birds which have got the full blast are sure to die when alighting at sea."

The fulmar chicks let fly at anyone coming near them, including adult fulmars. Homing parents always announce their arrival well before alighting. If they fail to do so, or if the dozing chick does not hear them and is startled by their landing, they are promptly sprayed. But although the oil can be lethal to other sea birds, fulmars can clean their feathers of it by repeated bathing and suffer no ill effect.

The parents arrive with food thrice daily, pouring about 150 grams of oil into their chick every twenty-four hours. Later this tapers off to a meal a day and finally, just before the parents leave, to a food visit every two or three days. The chicks weigh about 70 grams at the time of hatching and gain weight at an average rate of 25 grams a day. After a month, they are grotesquely obese. A few weigh 1,200 grams, twice the weight of their parents, although 700 to 1,000 grams is more common.

Having done their duty, the parents depart. The fulmar chicks squat on their nests like feathered blobs of fat and fast. Their plumage grows rapidly. They become more active and flex their wings. The first chicks glide down from the breeding ledges about September 10, and by the end of September all have left. Prince Leopold Island, already streaked with snow, is silent until its birds return again next spring.

Excerpted from the book *Number Our Days* by Barbara Myerhoff by permission of the publisher E.P. Dutton. Copyright © 1978 by Barbara Myerhoff

Number Our Days

by Barbara Myerhoff

Every morning I wake up in pain. I wiggle my toes. Good. They still obey. I open my eyes. Good. I can see. Everything hurts but I get dressed. I walk down to the ocean. Good. It's still there. Now my day can start. About tomorrow I never know. After all, I'm eighty-nine. I can't live forever

Death and the ocean are protagonists in Basha's life. They provide points of orientation, comforting in their certitude. One visible; the other invisible: neither hostile nor friendly, they accompany her as she walks down the boardwalk to the Aliyah Senior Citizens' Center.

Above all, Basha wants to remain independent. Her life at the beach depends on her ability to perform a minimum number of basic tasks. She must shop and cook, dress herself, care for her body and her one-room apartment, walk, take the bus to the market and the doctor, be able to make a telephone call in case of emergency. Her arthritic fingers have a difficult time with the buttons on her dress. Some days her fingers ache and swell so that she cannot fit them into the holes of the telephone dial. Her hands shake as she puts in her eyedrops for glaucoma.

Basha's daughter calls her once a week. She worries about her mother living alone and in a deteriorated neighborhood. "Don't worry about me, darling. This morning I put the garbage in the oven and the bagels in the trash. But I'm feeling fine." Basha enjoys teasing her daughter whose distant concern she finds somewhat embarrassing. "She says to me, 'Mamaleh, you're sweet but you're so *stupid*.' What else could a greenhorn mother expect from a daughter who is a lawyer?" The statement conveys Basha's simultaneous pride and grief at having produced an educated, successful child whose very accomplishments drastically separate her from her mother. The daughter has often invited Basha to live with her, but Basha refuses.

Like most of the three hundred or so elderly members (late eighties and beyond) of the Aliyah Center, Basha was born, and spent much of her childhood, in one of the small, predominately Jewish, Yiddish-speaking villages known as *shtetls*, located within the Pale of Settlement of Czarist Russia, an area to which almost half the world's Jewish population was confined in the nineteenth century. Desperately poor, regularly terrorized by outbreaks of anti-Semitism initiated by government officials and surrounding peasants, *shtetl* life was precarious. Yet, in these provincial, self-sufficient, semirural settlements, a rich, highly developed culture flourished, based on a shared, sacred religious history, common customs and beliefs,

and two languages—Hebrew for prayer and Yiddish for daily life. The folk culture, Yiddishkeit, reached its florescence there, and although it continues in various places in the world today, by comparison these expressions are dim and fading. When times worsened, Eastern Europe *shtetl* life often seemed to intensify proportionately. Internal ties deepened, and people drew sustenance and courage from each other, their religion, and their community. For many, life became unbearable under the reactionary regime of Czar Alexander II. The pogroms of 1881–82, accompanied by severe economic and legal restrictions, drove out the more desperate and daring of the Jews. Soon they were leaving the *shtetls* and the cities in droves. The exodus of Jews from Eastern Europe swelled rapidly; by the turn of the century, hundreds of thousands were emigrating, the majority to seek freedom and opportunity in the New World.

Even though she is now living in southern California, Basha dresses for the cold, wearing a babushka under a red sun hat, a sweater under her heavy coat. She moves steadily down the boardwalk, paying attention to the placement of her feet. A fall is common and dangerous for the elderly. A fractured hip can mean permanent disability, loss of autonomy, and removal from the community to a convalescent or old age home. Basha seats herself on a bench in front of the Center and waits for friends. Her feet are spread apart, well planted, as if growing up from the cement. Even sitting quite still, she has an air of determination about her. She will withstand attacks by anti-Semites, Cossacks, Nazis, historical enemies whom she conquers by outliving. She defies time and weather (although it is not cold here). So she might have sat a century ago, before a small pyramid of potatoes or herring in the marketplace of the Polish town where she was born. Patient, resolute, she is a survivor.

As the morning wears on, the benches fill. Benches are attached back to back: one side facing the ocean; one side the boardwalk. The people on the ocean side swivel around to face their friends, the boardwalk, and the Center.

Bench behavior is highly stylized. The half-dozen or so benches immediately to the north and south of the Center are the territory of the members, segregated by sex and conversation topic. The men's benches are devoted to abstract, ideological concerns—philosophical debates, politics, religion, and economics. The women's benches are given more to talk about immediate, personal matters—children, food, health, neighbors, love affairs, scandals, and "managing." Men and women talk about Israel and its welfare, about being a Jew, and about Center politics. On the benches, reputations are made and broken, controversies explored, leaders selected, factions formed and dissolved. Here is the outdoor dimension of Center life; like a village plaza, it is a focus of protracted, intense sociability. All the elderly Jews in the neighborhood are Eastern European in origin. All are multilingual. Hebrew is brought out—usually by the men—for punctuating debates with definitive, learned points. Russian or Polish may be used for songs, stories, poems, and reminiscences. But Yiddish, the beloved *mama-loshen*, "mother tongue," of their childhood, binds these diverse people together. It is Yiddish that is used for the most emotional discussions. Despite their ideological differences, most of these people know each other well, having lived here at the beach for two and three decades.

About thirty years ago, Jews from all over the country began to immigrate to the beach community, particularly those with health problems or newly retired. Seeking a benign climate, fellow Jews, and moderately priced housing, they brought their savings and small pensions and came to live near the ocean. Collective life was and still is especially intense in this community because there is no automobile traffic on the boardwalk. Here is a place where people may meet, gather, talk, and stroll—simple but basic and precious activities that the elderly in particular can enjoy here all year round.

In the late 1950s, an urban development program resulted in the displacement of between four and six thousand of these senior citizens in a very short period. It was a devastating blow to the culture. "A second Holocaust," Basha called it. "It destroyed our *shtetl* life all over again." Soon after the urban development project began, a marina was constructed at the southern end of the boardwalk. Property values soared. Older people could not pay the taxes and many lost their homes. Rents quadrupled. As old ho-

tels and apartments were torn down, housing became the most serious problem for the elderly who desperately wanted to remain in the area. While several thousand have managed to hang on, no new Center members are moving into the area because of the housing problem. Their Yiddish world, built up over a thirty-year period, is dying and extinction is imminent. Perhaps it will last another five or, at most, ten years. Whenever a Center member leaves, everyone is acutely aware that there will be no replacements. The sense of cultural doom coincides with awareness of approaching individual death. "When I go out of here, it will be in a box or to the old folks' home. I couldn't say which is worse," Basha said. "We've only got a few more years here, all of us. It would be good if we could stay till the end. We had a protest march the other day, when they took down the old Miramar Hotel. I made up a sign. It said, 'Let my people stay.'"

Yet the community is not a dreary place, and the Center members are not a depressed group. The sense of doom, by some miraculous process, functions to heighten and animate their life. Every moment matters. There is no time for deception, trivia, or decorum. Life at the Center is passionate, almost melodramatic. Inside, ordinary concerns and mundane interchanges are strangely intense, quickly heating to outburst. The emotional urgency often seems to have little to do with content. This caldronlike quality is perhaps due to the elders' proximity to death and the realization that their remaining days are few. They want to be seen and heard from, before it is too late.

Center culture is in some respects thin and fragile, but its very existence must be seen as a major accomplishment, emerging spontaneously as a result of two conditions that characterize the members: social isolation and continuities between past and present circumstance. Several marked similarities exist between the circumstances of members' childhoods and old age. They had grown up in small, intimate Jewish communities—isolated, ethnocentric, surrounded by indifferent and often hostile outsiders. Previously, in Eastern Europe, they had been marginal people, even pariahs. They had strong early training in resourcefulness and opportunities to develop strong survival strategies. Then, as now, they had been poor, politically impotent, and physically insecure. Then, as now, they turned to each other and their shared Yiddishkeit for sustenance, constituting what Irving Howe has called a "ragged kingdom of the spirit." It was not a great shock for these people to find themselves once more in difficult circumstances, for they had never given up their conviction that life was a struggle, that gains entailed losses, that joy and sorrow were inseparable. They knew how to pinch pennies, how to make do, how to pay attention to those worse off than they and thereby feel useful and needed. They had come to America seeking another life and found that it, too, provided some fulfillments, some disappointments. And thus, they were now not demoralized or helpless.

Their culture was able to emerge as fully as it did because of their isolation from family and community, ironically, the very condition that causes them much grief. Yet, their isolation freed them to find their own way. Now they could indulge their passion for things of the past, enjoy Yiddishkeit without fear of being stigmatized as "not American." With little concern for public opinion, with only each other for company, they revitalized selected features of their common history to meet their present needs, adding and amending it without concern for consistency, priority, or "authenticity." It had taken three decades for this culture to develop to its present state of complexity, now a truly organic, if occasionally disorderly and illogical, amalgam of forms and sentiments, memories and wishes, rotating around a few stable, strong symbols and premises. Claude Levi-Strauss has used the word *bricolage* to describe the process through which myths are constructed in preliterate societies. Odds and ends, fragments offered up by chance or the environment—almost anything will do—are taken up by a group and incorporated into a tale, used by a people to explain themselves and their world. No intrinsic order or system has dictated the materials employed. In such an inelegant fashion does the *bricoleur*, or "handyman," meet his needs.

Center culture was such a work of *bricolage*. Robust and impudently eclectic, it shifted and stretched to meet immediate needs—private, collective, secular, and sacred. Thus, when a Center Yiddish History class

graduated, a unique ceremony was designed that pasted together the local event with an analogous, historical counterpart, thereby enlarging and authenticating the improvised, contemporary affair. And the traditional Sabbath ceremony was rearranged to allow as many people as possible to participate—making speeches, singing songs, reading poems—taking into account the members' acute need for visibility and attention. Two or even three women, instead of one, were required to light the Sabbath candles—one singing the blessing in Hebrew, one in Yiddish, one putting the match to the wick. Similarly, Center folk redefined the secular New Year's Eve, holding their dance a full day and a half before the conventional date, since this made it possible for them to get home before dark and to hire their favorite musicians at lower rates. These improvisations were entirely authentic. Somehow, midday December 30 became the real New Year's Eve and the later, public celebration seemed unconvincing by comparison. In all this, no explicit plan or internal integration could be detected. Cultures are, after all, collective, untidy assemblages, authenticated by belief and agreement, focused only in crisis, systematized after the fact. Like a quilt, Center life was made up of many small pieces sewn together by necessity, intended to be serviceable and to last. It was sufficient for the people's remaining years.

I had made no conscious decision to explore my roots or clarify the meaning of my origins. I was one of several anthropologists at the University of Southern California engaged in an examination of ethnicity and aging. At first I planned to study elderly Chicanos, since I had previously done fieldwork in Mexico. But in the early 1970s in urban America, ethnic groups were not welcoming curious outsiders, and people I approached kept asking me, "Why work with us? Why don't you study your own kind?" This was a new idea to me. I had not been trained for such a project. Anthropologists conventionally investigate exotic, remote, preliterate societies. But such groups are increasingly unavailable and often inhospitable. As a result, more and more anthropologists find themselves working at home these days. Inevitably, this creates problems with objectivity and identification, and I anticipated that I, too, would have my share if I studied the Center folk. But perhaps there would be advantages. There was no way that I could have anticipated the duration of the study or its great impact on my life. I intended to spend a year at the Center. In fact, I was there continually for two years (1973–74, 1975–76) and periodically for two more. In the beginning, I spent a great deal of time agonizing about how to label what I was doing—was it anthropology or a personal quest? I never fully resolved the question. I used many conventional anthropological methods and asked many typical questions, but when I had finished, I found my descriptions did not resemble most anthropological writings. Still, the results of the study would certainly have been different had I not been an anthropologist.

Sitting in the sun and contemplating the passing parade on the boardwalk that first morning in 1973, I wondered how to begin. At eleven-thirty the benches began to empty as old people entered the Center for a "Hot Kosher Meal—Nutritious—65¢," then a new program provided by state and private funds. I followed the crowd inside and sat at the back of the warm, noisy room redolent with odors of fish and chicken soup, wondering how to introduce myself. It was decided for me when a woman, who I soon learned was Basha, sat down next to me. In a leisurely fashion, she appraised me. Uncomfortable, I smiled and said hello.

"You are not hungry?" she asked.

"No, thank you, I'm not," I answered.

"So, what brings you here?"

"I'm from the University of Southern California. I'm looking for a place to study how older Jews live in the city."

At the word *university*, she moved closer and nodded approvingly. "Are you Jewish?" she asked.

"Yes, I am."

"Are you married?" she persisted.

"Yes."

"You got children?"

"Yes, two boys, four and eight," I answered.

"Are you teaching them to be Jews?"

"I'm trying."

"So what do you want with us here?" asked Basha.

"Well, I want to understand your life, find out what it's like to be older and Jewish, what if anything makes

Jews different from other older people. I'm an anthropologist and we usually study people's cultures and societies. I think I would like to learn about this culture."

"And what will you do for us?" she asked me.

"I could teach a class in something people here are interested in—how older people live in other places, perhaps."

"Are you qualified to do this?" Basha shot me a suspicious glance.

"I have a Ph.D. and have taught in the university for a number of years, so I suppose I am qualified."

"You are a professor then? A little bit of a thing like you?" To my relief, she chuckled amiably. Perhaps I had passed my first rite of entrance into the group.

For the next four years I was to be involved with these people, as an anthropologist doing fieldwork, as a friend, and sometimes, as a family member. The anthropologist engages in peculiar work. He or she tries to understand a different culture to the point of finding it to be intelligible, regardless of how strange it seems in comparison with one's own background. This is accomplished by attempting to experience the new culture from within, living in it for a time as a member, all the while maintaining sufficient detachment to observe and analyze it with some objectivity. This peculiar posture—being inside and outside at the same time—is called participant-observation. It is a fruitful paradox, one that has allowed anthropologists to find sense and purpose within a society's seemingly illogical and arbitrary customs and beliefs. This assumption of the natives' viewpoint, so to speak, is a means of knowing others through oneself, a professional technique that can be mastered fairly easily in the study of very different peoples. Working with one's own society, and more specifically, those of one's own ethnic and familial heritage, is perilous and much more difficult. Yet it has a certain validity and value not available in other circumstances. Identifying with the "other"—Indians and Chicanos if one is Anglo, blacks if one is white, males if one is female—is an act of imagination, a means for discovering what one is not and will never be. Identifying with what one is now and will be someday is quite a different process. And one day I will

be a little old Jewish lady, and it is important for me to have some concrete expectations about that.

In working among the elderly—also, I suspect, among the very young—an exceptionally important part of one's information is derived from nonverbal communication and identification, this because the bodily state is such a large determinant of well-being for the growing and declining organism. At various times, I consciously tried to heighten my awareness of the physical state of the elderly by wearing stiff garden gloves to perform ordinary tasks, taking off my glasses and plugging my ears, slowing down my movements and, sometimes, by wearing the heaviest shoes I could find to the Center. Walking a few blocks in this condition became an unimaginably exhilarating achievement. Once by accident I stumbled slightly. The flash of terror I experienced was shocking. From close watching of the elderly, it seems I had acquired their need to avoid falling, although to one of my age and in good health, such a minor accident presents no real danger. This recognition occurred after I had been watching two very old women walk down the alley with great concentration, arms tightly linked, navigating impediments in slow-motion movements that were perfectly coordinated and mutually supportive. So great was their concern with balance, they might have been walking a high wire.

But I learned more than what old age would or could be in my work with the Center elderly. They provided a model of an alternative life style, built on values in many ways antithetical to those commonly esteemed by contemporary Americans. The usual markers of success were anathema to them. Wealth, power, physical beauty, youth, mobility, security, social status—all were out of the question. Without a future, lacking hope for change or improvement, they had devised a counterworld, inventing their own version of what made "the good life." It was built on their veneration for their religious and cultural membership and was full of meaning, intensity, and consciousness. This they had managed on their own, creating a nearly invisible, run-down world, containing a major lesson for any who would attend it. It was not the first time that an anthropologist had found in obscure, unworldly folk a message of wide appli-

cability for the larger outside society.

The character of Center social life was distinctively tumultuous and dramatic. In part this was due to the tensions arising from contradictions within the members' ideology, most conspicuously, between their Zionism and internationalism, their agnosticism and Judaism, their identification with modern American society and their Eastern European past. All cultures are riddled with internal inconsistencies, but they do not generally produce the kind of social disorganization so evident at the Center. More troublesome than the inconsistencies in their beliefs were certain paradoxes or structural conflicts that disrupted solidarity and prevented their society from developing the stability it otherwise might have. Three paradoxes were particularly evident. First was people's need for passionate experiences, as opposed to their desire for dignity and harmony. Second, people had extreme need for each other socially and psychologically, with no corresponding material, economic need; this resulted in a peculiar imbalance that generated much strain and confusion. Finally, Center elders required witnesses to their past and present life and turned to each other for this, although it is a role properly filled by the succeeding generation. Lacking suitable heirs to their traditions and stories, they were forced to use peers who, they realized, would perish along with them, and thus could not assure the preservation of what they had witnessed.

Center people, like so many of the elderly, were very fond of reminiscing and storytelling, eager to be heard from, eager to relate parts of their life history. More afraid of oblivion than of pain or death, they always sought opportunities to become visible. Narrative activity among them was intense and relentless. Age and proximity to death augmented the Jewish predilection for verbal expression. In their stories, as in their cultural dramas, they witnessed themselves, and thus knew who they were, serving as subject and object at once. They perpetually narrated themselves; they kept notes and journals, wrote poems and spontaneous reflections, and told their stories to all who would listen. Their histories were not devoted to marking their successes or unusual merits. Rather they were efforts at ordering, sorting, explaining—rendering coherent their long lives, finding integrating ideas and characteristics that helped them know themselves as the same persons over time, despite great ruptures and shifts. No doubt their emigrant experience and the loss of their original culture made them even more prone to seek continuity and coherence. Survivors, it is often noted, are strongly impelled to serve as witnesses to what has been lost. Often these materials are idealized and sentimentalized. Despite its poverty and oppression, *shtetl* life was often described as a golden age in comparison with much of the present, which was found lacking. In recounting the past, they kept that early life alive, weaving it into their present.

Here are excerpts from a statement dictated by Shmuel, one of the Center members and my principal informant. He died three days after he completed recording his life history.

"Oh, how often in our dreams, like a bird, we fly back to the place of our birth, to that little Polish town on the Vistula, which would be to you a small speck on the map, maybe even too insignificant for a map. A few thousand people huddled together, hidden in the hills, but with a view in sight of the beautiful river. In this place, the population was nearly equal Poles and Jews. All were poor. There were the poor and the poorer still.

"If you walked through the Jewish quarter, you would see small houses, higgledy-piggledy, leaning all over each other. Some had straw roofs, if shingles, some broken. No cobbles on the streets, and you might not even want to call them streets, so narrow and deep rutted from wagons. Everywhere, children, cats, geese, chickens, sometimes a goat, all together making very strong smells and noises. Always, the children were dirty and barefoot, always the dogs were skinny and mean, not Jewish dogs. They came over from Gentile quarters looking for garbage and cats. You would go along this way until you crossed the wooden bridge into the main *platz*. Here were the women on market day, sitting in the open, or in little wooden stalls if they were well off.

"The pogroms were all around us. Then the soldiers on horseback would tear through the town and leave dead Jews behind. One time, we heard the

big bell ring out and there was no reason for it. We were so scared we hid in the synagogue. That was probably the worst place to go, but we were small boys. All night we stayed huddling together there and heard terrible noises outside—horses, screams, shouts. We were afraid to light the lamps or stove. In the morning some men came to get us. Someone, it must have been a Pole, had warned the Jews with the bells that the soldiers were coming through. Everyone got away very quickly, hiding in the forest and in neighbors' homes. Who knows what would have happened without the warning? As it is, the soldiers tore up the Jewish streets, broke windows, threw the furniture out. We came out into the sparkling sunshine and the streets were white like in winter. Everywhere were feathers from where those Cossacks cut up our featherbeds. Dead animals also on our streets.

"The day comes to go. A summer day, beautiful. My father goes down to the cemetery and I with him. I couldn't stand to go too close to him. I loved him, but the pain that was coming out from him kept me away. Like flames, going out in waves. First he walked up and down. Finally, he gave the rabbi there some money to say prayers and keep up the graves. Then he walked over to the grave of his father. He cried, tears coming down his face. His hair was black and gray. Old as he was, there was a youthfulness about him, very remarkable. At this time, I saw that youthfulness go out from him forever, like the departure of a spirit. I could not take this sight in, and I hid my eyes. Still, when I looked up, he stood there like a small boy crying. He walked over to the other graves, his mother's, his sisters' and brothers', then back to his father's. He started a conversation there, telling his father why he was leaving, asking him for forgiveness and a blessing. All the while his tears are running through his beard until his shirt front is drenched.

"In that little town there were no walls. But we were curled up together inside it, like small cubs, keeping each other warm, growing from within, never showing the outside what is happening, until our backs made up a strong wall. It is not the worst thing that can happen for a man to grow old and die. But here is the hard part. When my mind goes back there now, there are no roads going in or out. No way back remains because nothing is there, no continuation. Then life itself, what is its worth to us? Why have we bothered to live? All this is at an end. For myself, growing old would be altogether a different thing if that little town was there still. All is ended. So in my life, I carry with me everything—all those people, all those places, I carry them around until my shoulders bend. I can see the old rabbi, the workers pulling their wagons, the man carrying his baby tied to his back, walking up from the Vistula, no money, no house, nothing to feed his child. His greatest dream is to have a horse of his own, and in this he will never succeed. So I carry him. If he didn't have a horse, he should have at least the chance to be remaining in the place he lived. Even with all that poverty and suffering, it would be enough if the place remained, even old men like me, ending their days, would find it enough. But when I come back from these stories and remember that the way they lived is gone forever, wiped out like you would erase a line of writing, then it means another thing altogether for me to accept leaving this life. If my life goes now, it means nothing. But if my life goes, with my memories, and all that is lost, that is something else to bear." □

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Piltdown Revisited

The greatest mystery is not who did it but why the forgery worked

Nothing is quite so fascinating as a well-aged mystery. Many connoisseurs regard Josephine Tey's *The Daughter of Time* as the greatest detective story ever written because its protagonist is Richard III, not the modern and insignificant murderer of Roger Ackroyd. The old chestnuts are perennial sources for impassioned and fruitless debate. Who was Jack the Ripper? Was Shakespeare Shakespeare?

My profession of paleontology offered its entry to the first rank of historical conundrums a quarter-century ago. In 1953, Piltdown man was exposed as a certain fraud perpetrated by a very uncertain hoaxer. Since then, interest has never flagged. People who cannot tell *Tyrannosaurus* from *Allosaurus* have firm opinions about the identity of Piltdown's forger. Rather than simply ask "whodunnit?" this column treats what I regard as an intellectually more interesting issue: why did anyone ever accept Piltdown man in the first place? I was led to address the subject by recent and prominent news reports adding—with abysmally poor evidence, in my opinion—yet another prominent suspect to the list. Also, as an old mystery reader, I cannot refrain from expressing my own prejudice, all in due time.

In 1912, Charles Dawson, a lawyer and amateur archeologist from Sussex, brought several cranial fragments to Arthur Smith Woodward, Keeper of Geology at the British Museum (Natural History). The first, he said, had been unearthed by workmen from a gravel pit in 1908. Since then, he had searched the spoil heaps and found a few more fragments. The bones, worn and deeply stained, seemed indigenous to the ancient gravel; they were not the remains of a more recent interment. Yet the skull appeared remarkably modern in form, although the bones were unusually thick.

Smith Woodward, excited as such a measured man could be, accompanied Dawson to Piltdown and there, with Father Teilhard de Chardin, looked for further evidence in the spoil heaps. (Yes, believe it or not, the same Teilhard who, as a mature scientist and theologian, became such a cult figure some fifteen years ago with his attempt to reconcile evolution, nature, and God in *The Phenomenon of Man*. Teilhard had come to England in 1908 to study at the Jesuit College in Hastings, near Piltdown. He met Dawson in a quarry on May 31, 1909; the mature solicitor and the young French Jesuit became warm friends, colleagues, and coexplorers.)

On one of their joint expeditions, Dawson found the famous mandible, or lower jaw. Like the skull fragments, the jaw was deeply stained, but it seemed to be as apish in form as the

Lower molars of the Piltdown jaw AMNH

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cranium was human. Nonetheless, it contained two molar teeth, worn flat in a manner not rare in humans but never encountered in apes. Unfortunately, the jaw was broken in just the two places that might have settled its relationship to the skull: the chin region, with all its marks of distinction between ape and human, was gone, and so was the area of articulation with the cranium.

Armed with skull fragments, the lower jaw, and an associated collection of worked flints and bone, plus a number of mammalian fossils to fix the age as ancient, Smith Woodward and Dawson made their splash before the Geological Society of London on December 18, 1912. Their reception was mixed, although on the whole favorable. Although no one smelled fraud, the association of such a human cranium with such an apish jaw indicated to some critics that remains of two separate animals might have been mixed together in the quarry.

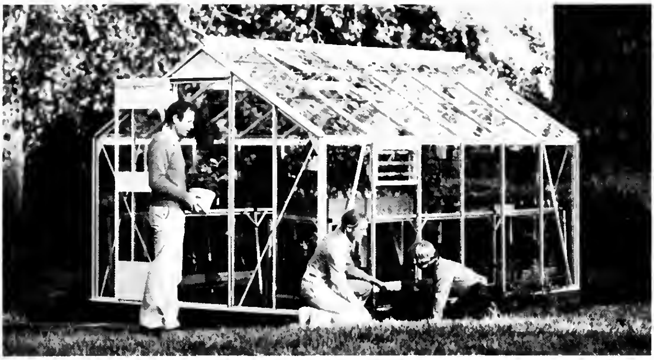
Over the next three years, Dawson and Smith Woodward countered with a series of further discoveries that, in retrospect, could not have been better programmed to dispel doubt. In 1913, Father Teilhard found the all-important lower canine tooth. It, too, was apish in form but strongly worn in a human manner. Then, in 1915, Dawson convinced most of his detractors by finding the same association of two thick-skulled human cranial fragments with an apish tooth worn in a human manner at a second site two miles from the original finds.

Henry Fairfield Osborn, leading American paleontologist and converted critic, wrote:

> If there is a Providence hanging over the affairs of prehistoric men, it certainly manifested itself in this case, because the three fragments of the second Piltdown man found by Dawson are exactly those which we would have selected to confirm the comparison with the original type. . . . Placed side by side with the corresponding fossils of the first Piltdown man they agree precisely; there is not a shadow of a difference.

Providence, unbeknownst to Osborn, walked in human form at Piltdown.

For the next thirty years, Piltdown occupied an uncomfortable but acknowledged place in human prehistory. Then, in 1949, Kenneth P. Oakley applied his fluorine test to the Piltdown remains. Bones pick up fluorine in proportion to their time of residence in a deposit and the fluorine content of



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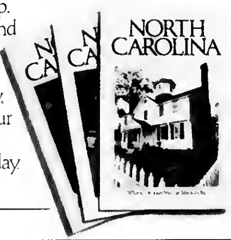

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the deposit. Both the skull and jaw of Piltdown contained barely detectable amounts of fluorine; they could not have lain long in the gravels. Oakley still did not suspect fakery. He proposed that Piltdown, after all, had been a relatively recent interment into ancient gravels.

But a few years later, in collaboration with J.S. Weiner and W.E. le Gros Clark, Oakley finally considered the obvious alternative—that the "interment" had been made in this century with intent to defraud. He found that the skull and jaw had been artificially stained, the flints and bone worked with modern blades, and the associated mammals, although genuine fossils, imported from elsewhere. Moreover, the teeth had been filed down to simulate human wear. The old anomaly—an apish jaw with a human cranium—was resolved in the most parsimonious way of all. The skull *did* belong to a modern human; the jaw was an orangutan's.

But who had foisted such a monstrous hoax upon scientists so anxious for such a find that they remained blind to an obvious resolution of its anomalies? Of the original trio, Teilhard was dismissed as a young and unwitting dupe. No one has ever (and rightly, in my opinion) suspected Smith Woodward, the superstraight arrow who devoted his life to the reality of Piltdown and who, past eighty and blind, dictated in retirement his last book with its chauvinistic title, *The Earliest Englishman* (1948).

Suspicion instead has focused on Dawson. Opportunity he certainly had, although no one has ever established a satisfactory motive. Dawson was a highly respected amateur with several important finds to his credit. He was overenthusiastic and uncritical, perhaps even a bit unscrupulous in his dealings with other amateurs, but no direct evidence of his complicity has ever come to light. Nevertheless, the circumstantial case is strong and well summarized by J.S. Weiner in *The Piltdown Forgery* (Oxford University Press, 1955).

Supporters of Dawson have maintained that a more professional scientist must have been involved, at least as a coconspirator, because the finds were so cleverly faked. I have always regarded this as a poor argument, advanced by scientists largely to assuage their embarrassment that such an indifferently designed hoax was not detected sooner. The staining, to be sure, had been done consummately. But the "tools" had been poorly carved and the teeth rather crudely filed—scratch marks were noted as soon as scientists looked with the right hypothesis in mind. Le Gros Clark wrote: "The evidences of artificial abrasion immediately sprang to the eye. Indeed so obvious did they seem it may well be asked—how was it that they had escaped notice before." The forger's main skill consisted in knowing what to leave out—discarding the chin and articulation.

Piltdown reappeared prominently in the news last November because yet another scientist has been implicated as a possible coconspirator. Shortly before he died last year at age ninety-three, J.A. Douglas, emeritus professor of geology at Oxford, made a tape recording suggesting that his predecessor in the chair, W.J. Sollas, was the culprit. In support of this assertion, Douglas offered only three items scarcely ranking as evidence in my book: (1) Sollas and Smith Woodward were bitter enemies. (So what. Academia is a den of vipers, but verbal sparring and elaborate hoaxing are responses of differing magnitude.) (2) In

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1910, Douglas gave Sollas some mastodon bones that could have been used as part of the imported fauna. (But such bones and teeth are not rare.) (3) Sollas once received a package of potassium bichromate and neither Douglas nor Sollas's photographer could figure out why he had wanted it. Potassium bichromate was used in staining the Piltdown bones. (It was also an important chemical in photography, and I do not regard the supposed confusion of Sollas's photographer as a strong sign that the professor had some nefarious usages in mind.) In short, I find the evidence against Sollas so weak that I wonder why the leading scientific journals of England and the United States gave it so much space. I would exclude Sollas completely, were it not for the paradox that his famous work on *Ancient Hunters* supports Smith Woodward's views about Piltdown in terms so obsequiously glowing that it could be read as subtle sarcasm.

Only three hypotheses make much sense to me. First, Dawson was widely suspected and disliked by some amateur archeologists (and equally acclaimed by others). Some compatriots regarded him as a fraud. Others were bitterly jealous of his standing among professionals. Perhaps one of his colleagues devised this complex and peculiar form of revenge. The second hypothesis, and the most probable in my view, holds that Dawson acted alone, whether for fame or to show up the world of professionals we do not know.

The third hypothesis is much more interesting. It would render Piltdown as a joke that went too far, rather than a malicious forgery. It represents the "pet theory" of many prominent vertebrate paleontologists who knew the man well. I have sifted all the evidence, trying hard to knock it down. Instead, I find it consistent and plausible, although not the leading contender. A.S. Romer, late head of the museum I inhabit at Harvard and America's finest vertebrate paleontologist, often stated his suspicions to me. Louis Leakey also believed it. His autobiography refers anonymously to a "second man," but internal evidence clearly implicates a certain individual to anyone in the know.

It is often hard to remember a man in his youth after old age imposes a different persona. Teilhard de Chardin became an austere and almost Godlike figure to many in his later years; he was widely hailed as a leading prophet of our age. But he was once a fun-loving young student. He knew Dawson for three years before Smith Woodward entered the story. He may have had access, from a previous assignment in Egypt, to mammalian bones (probably from Tunisia and Malta) that formed part of the "imported" fauna at Piltdown. I can easily imagine Dawson and Teilhard, over long hours in field and pub, hatching a plot for different reasons: Dawson to expose the gullibility of pompous professionals; Teilhard to rub English noses once again with the taunt that their nation had no legitimate human fossils, while France reveled in a superabundance that made her the queen of anthropology. Perhaps they worked together, never expecting that the leading lights of English science would fasten to Piltdown with such gusto. Perhaps they expected to come clean but could not.

Teilhard left England to become a stretcher bearer during World War I. Dawson, on this view, persevered and completed the plot with a second Piltdown find in 1915. But then the joke ran away and became a nightmare. Dawson sickened unexpectedly and died in 1916. Teilhard could not return

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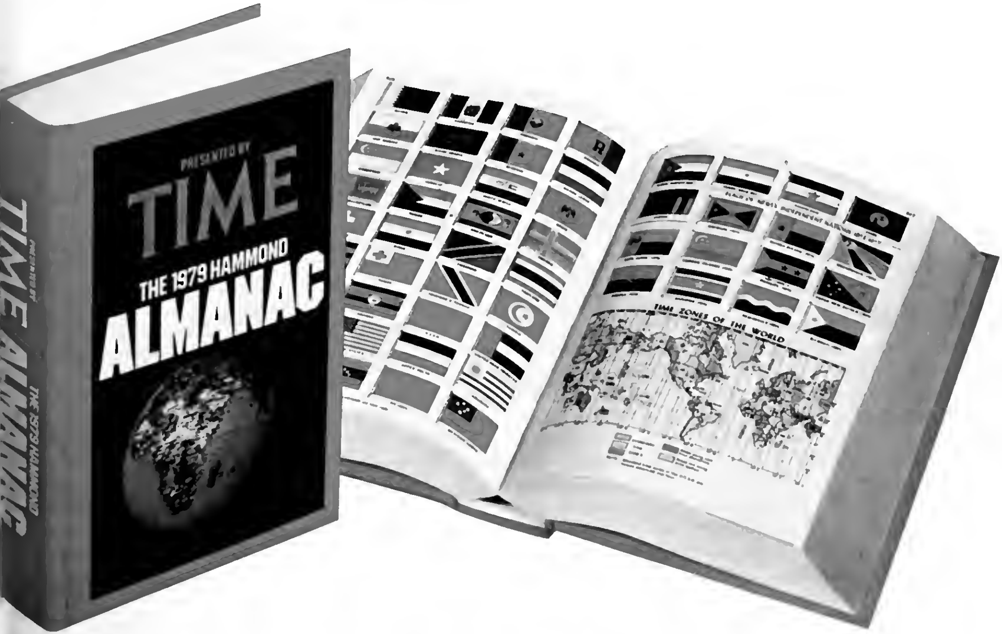

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before the war's end. By that time, the three leading lights of British anthropology and paleontology—Arthur Smith Woodward, Grafton Elliot Smith, and Arthur Keith—had staked their careers on the reality of Piltdown. (Indeed they ended up as two Sir Arthurs and one Sir Grafton, largely for their part in putting England on the anthropological map.) Had Teilhard confessed in 1918, his promising career (which later included a major role in describing the legitimate Peking man) would have ended abruptly. So he followed the Psalmist and the motto of Sussex University, later established just a few miles from Piltdown—"Be still, and know. . . ."—to his dying day. Possible. Just possible.

All this speculation provides endless fun and controversy, but what about the prior and more interesting question: why had anyone believed Piltdown in the first place? It was an improbable creature from the start. Why had anyone admitted to our lineage an ancestor with a fully modern cranium and the unmodified jaw of an ape?

Indeed, Piltdown never lacked detractors. Its temporary victory was born in conflict and nurtured throughout by controversy. Many scientists continued to believe that Piltdown was an artifact composed of two animals accidentally commingled in the same deposit. In the early 1940s, for example, Franz Weidenreich, perhaps the world's greatest human anatomist, wrote (with devastating accuracy in hindsight): "*Eoanthropus* ['dawn man,' the official designation of Piltdown] should be erased from the list of human fossils. It is the artificial combination of fragments of a modern human braincase with orang-utang-like mandible and teeth." To this apostasy, Sir Arthur Keith responded with bitter irony: "This is one way of getting rid of facts which do not fit into a preconceived theory; the usual way pursued by men of science is, not to get rid of facts, but frame theory to fit them."

Moreover, had anyone been inclined to pursue the matter, there were published grounds for suspecting fraud from the start. A dental anatomist, C.W. Lyne, stated that the canine found by Teilhard was a juvenile tooth, just erupted before Piltdown's death, and that its intensity of wear could not be reconciled with its age. Others voiced strong doubts about the ancient manufacture of Piltdown's tools. In amateur circles of Sussex, some of Dawson's colleagues concluded that Piltdown must be a fake, but they did not publish their beliefs.

If we are to learn anything about the nature of scientific inquiry from Piltdown—rather than just reveling in the joys of gossip—we will have to resolve the paradox of its easy acceptance. I think that I can identify at least four categories of reasons for the ready welcome accorded to such a misfit by all the greatest English paleontologists. All four contravene the usual mythology about scientific practice—that facts are "hard" and primary and that scientific understanding increases by patient collection and fitting together of these objective bits of pure information. Instead, they display science as a human activity, motivated by hope, cultural prejudice, and the pursuit of glory yet stumbling in its erratic path toward a better understanding of nature.

The imposition of strong hope upon dubious evidence. Before Piltdown, English paleoanthropology was mired in a limbo now occupied by students of extraterrestrial life: endless fields for speculation and no direct evidence. Beyond some flint "cultures" of

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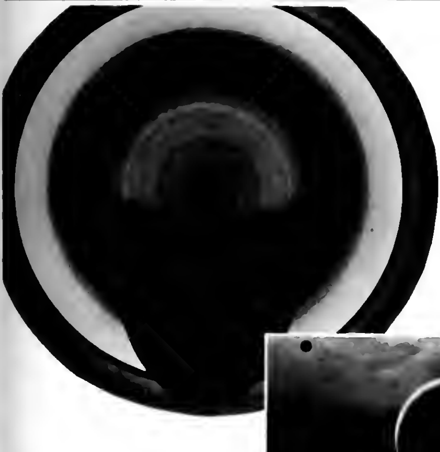
doubtful human workmanship and some bones strongly suspected as products of recent interments into ancient gravels, England knew nothing of its most ancient ancestors. France, on the other hand, had been blessed with a superabundance of Neanderthals and Cro-Magnons and their associated art and tools. And French anthropologists delighted in rubbing English noses with this marked disparity of evidence. Piltdown could not have been better designed to turn the tables. It seemed to predate Neanderthal by a considerable stretch of time. If human fossils had a fully modern cranium hundreds of thousands of years before beetle-browed Neanderthal appeared, then Piltdown must be our ancestor and the French Neanderthals a side branch. Smith Woodward proclaimed: "The Neanderthal race was a degenerate offshoot of early man while surviving modern man may have arisen directly from the primitive source of which the Piltdown skull provides the first discovered evidence." This international rivalry has often been mentioned by Piltdown's commentators, but a variety of equally important factors have usually escaped notice.

Reduction of anomaly by fit with cultural biases. A human cranium with an ape's jaw strikes us today as sufficiently incongruous to merit strong suspicion. Not so in 1913. In a previous column (November 1975) I wrote about the strong influences exerted by biases, largely cultural in origin, for "brain primacy" in human evolution. The argument rested on a false inference from contemporary importance to historical priority: We rule today by virtue of our intelligence. Therefore, in our evolution, an enlarged brain must have preceded and inspired all other alterations of our body. We should expect to find human ancestors with enlarged, perhaps nearly modern, brains and a distinctly simian body. (Ironically, nature followed an opposite path. Our earliest ancestors, the australopithecines, were fully erect but still small brained.) Thus, Piltdown neatly matched a widely anticipated result. Grafton Elliot Smith wrote in 1924:

> The outstanding interest of the Piltdown skull is in the confirmation it affords of the view that in the evolution of Man the brain led the way. It is the veriest truism that Man has emerged from the simian state in virtue of the enrichment of the structure of his mind. . . . The brain attained what may be termed the human rank at a time when the jaws and face, and no doubt the body also, still retained much of the uncouthness of Man's simian ancestors. In other words, Man at first . . . was merely an Ape with an overgrown brain. The importance of the Piltdown skull lies in the fact that it affords tangible confirmation of these inferences.

Piltdown also buttressed some all too familiar racial views among white Europeans. In the 1930s and 1940s, following the discovery of Peking man in strata approximately equal in age with the Piltdown gravels, phyletic trees based on Piltdown and affirming the antiquity of white supremacy began to appear in the literature (although they were never adopted by Piltdown's chief champions, Smith Woodward, Smith, and Keith). Peking man (originally called Sinanthropus, but now placed in *Homo erectus*) lived in China with a brain two-thirds modern size, while Piltdown man, with its fully developed brain, inhabited England. If Piltdown, as the earliest Englishman, was the progenitor of white races, while other hues must trace their ancestry to *Homo erectus*, then whites crossed the threshold to full humanity long before other people. As longer residents in this exalted state, whites



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Reducation of anomaly by matching fact to expectation. We know, in retrospect, that Piltdown had a human cranium and an ape's jaw. As such, it provides an ideal opportunity for testing what scientists do when faced with uncomfortable anomaly. G.E. Smith and others may have advocated an evolutionary head start for the brain, but no one dreamed of an independence so complete that brains might become fully human before jaws changed at all! Piltdown was distressingly too good to be true.

If Keith was right in his taunt to Weidenreich, then Piltdown's champions should have modeled their theories to the uncomfortable fact of a human cranium and an ape's jaw. Instead, they modeled the "facts"—another illustration that information always reaches us through the strong filters of culture, hope, and expectation. As a persistent theme in "pure" description of the Piltdown remains, we learn from all its major supporters that the skull, although remarkably modern, contains a suite of definitely simian characters! Smith Woodward, in fact, originally estimated the cranial capacity at a mere 1,070 cc (compared with a modern average of 1,400 to 1,500), although Keith later convinced him to raise the figure nearer to the low end of our modern spectrum. Grafton Elliot Smith, describing the brain cast in the original paper of 1913, found unmistakable signs of incipient expansion in areas that mark the higher mental faculties in modern brains. He concluded: "We must regard this as being the most primitive and most simian human brain so far recorded; one, moreover, such as might reasonably have been expected to be associated in one and the same individual with the mandible which so definitely indicates the zoological rank of its original possessor." Just a year before Oakley's revelation, Sir Arthur Keith wrote in his last major work (1948): "His forehead was like that of the orang, devoid of a supraorbital torus; in its modeling his frontal bone presented many points of resemblance to that of the orang of Borneo and Sumatra." Modern *Homo sapiens*, I hasten to add, also lacks a supraorbital torus, or brow ridge.

Careful examination of the jaw also revealed a set of remarkably human features for such an apish jaw (beyond the forged wear of the teeth). Sir Arthur Keith repeatedly emphasized, for example, that the teeth were inserted

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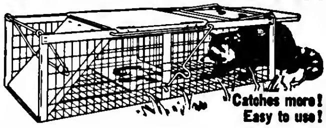

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into the jaw in a human, rather than a simian, fashion.

Prevention of discovery by practice. In former years, the British Museum did not occupy the vanguard in maintaining open and accessible collections—a happy trend of recent years, and one that has helped to lift the odor of mustiness (literally and figuratively) from major research museums. Like the stereotype of a librarian who protects books by guarding them from use, Piltdown's keepers severely restricted access to the original bones. Researchers were often permitted to look but not touch; only the set of plaster casts could be handled. Everyone praised the casts for their accuracy of proportion and detail, but the detection of fraud required access to the originals—artificial staining and wear of teeth cannot be discovered in plaster. Louis Leakey writes in his autobiography:

> As I write this book in 1972 and ask myself how it was that the forgery remained unmasked for so many years, I have turned my mind back to 1933, when I first went to see Dr. Bather, Smith Woodward's successor. . . . I told him that I wished to make a careful examination of the Piltdown fossils, since I was preparing a textbook on early man. I was taken into the basement to be shown the specimens, which were lifted out of a safe and laid on a table. Next to each fossil was an excellent cast. I was not allowed to handle the originals in any way, but merely to look at them and satisfy myself that the casts were really good replicas. Then, abruptly, the originals were removed and locked up again, and I was left for the rest of the morning with only the casts to study.
>
> It is my belief now that it was under these conditions that all visiting scientists were permitted to examine the Piltdown specimens, and that the situation changed only when they came under the care of my friend and contemporary Kenneth Oakley. He did not see the necessity of treating the fragments as if they were the crown jewels but, rather, considered them simply as important fossils—to be looked after carefully, but from which the maximum scientific evidence should be obtained.

Henry Fairfield Osborn, although not known as a generous man, paid almost obsequious homage to Smith Woodward in his treatise on the historical path of human progress, *Man Rises to Parnassus* (1927). He had been a skeptic before his visit to the British Museum in 1921. Then, on Sunday morning, July 24, "after attending a most memorable service in Westminster Abbey," Osborn "repaired to the British Museum to see the fossil remains of the now thoroughly vindicated Dawn Man of Great Britain." (He, at least, as head of the American Museum of Natural History, got to see the originals.) Osborn swiftly converted and proclaimed Piltdown "a discovery of transcendant importance to the prehistory of man." He then added: "We have to be reminded over and over again that Nature is full of paradoxes and that the order of the universe is not the human order." Yet Osborn had seen little but the human order on two levels—the comedy of fraud and the subtler, yet ineluctable, imposition of theory upon nature. Somehow, I am not distressed that the human order must veil all our interactions with the universe, for the veil is translucent, however strong its texture.

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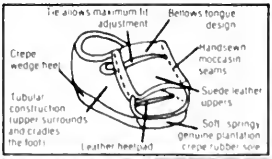

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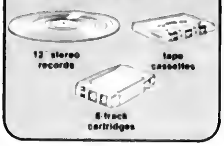

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Pluto's Moon

The outermost planet in the solar system has a satellite whose recent discovery has evoked a wave of conjecture

Almost fifty years after the discovery of Pluto, astronomers have found that it has a moon. Preliminary analyses of this finding have dramatically revised our understanding of the coldest and most distant of the nine known planets. The studies have revived earlier speculations that Pluto is itself an escaped moon of Neptune and that there may be an additional, even more distant planet—larger than the earth—that awaits discovery in the remote outskirts of the solar system.

Tentatively named Charon, Pluto's moon was found on June 22, 1978, by James W. Christy, a specialist in stellar measurements at the U.S. Naval Observatory in Washington, D.C. Christy was using STARSCAN, the observatory's high-precision measuring machine, to determine Pluto's position on photographs made in April and May of 1978 with a 60-inch telescope in Flagstaff, Arizona, when he noticed that the planet's images were elongated rather than circular. The photographs looked as though a fainter object existed right next to Pluto, so that the elongated image was really a very close pair of images.

Two proximate images of this sort would be produced if, for example, a faint background star happened to lie in virtually the same direction as the slow-moving planet at the time a photograph was made. However, as Pluto moved along from one day to the next, the star, if one existed, should have been left behind, so that the double image should not have been repeated, unless another faint star happened to be in exactly the right place at the right time. A check of the Palomar Observatory Sky Survey showed that there are no stars alongside Pluto's track through the heavens on the dates when the Flagstaff photographs were made. This indicated that the small object must be moving along with Pluto. Hence it must be a moon.

The discovery came shortly before Pluto was lost in the sun's glare, owing to the earth's motion around the sun. Although the existence of Charon apparently was confirmed at the Cerro Tololo Inter-American Observatory in La Serena, Chile, where an astronomer reported that Pluto's image was elongated in the expected direction on July 6, further observations are needed. These will be obtained during 1979, and analysis may then lead to revisions in the details of the strange properties of Pluto and Charon that we are about to consider.

The orbital motion of Charon has been analyzed, along with a few previously known facts about Pluto, by Christy and Robert S. Harrington, an astronomer at the Naval Observatory. They concluded that Charon is orbiting around Pluto once every 6.4 earth days, which thus constitutes a Plutonian month. This period, 6.4 days, equals the length of time that Pluto takes to turn once around its axis—a Plutonian day. Thus, the moon and planet are locked in synchrony, like partners revolving in an eternal waltz, and Charon seems to hang perpetually suspended over the same region of the planet.

The Pluto–Charon system is very different from our earth–moon system. The moon is never absent from our sky but we always see the same side of it from the earth—never the back. From one hemisphere of Pluto, Charon is always visible; from the opposite hemisphere, it can never be seen. Charon's orbit does not resemble our moon's but rather that of a communications satellite stationed over the Atlantic Ocean to relay telephone calls and broadcasts between Europe and North America and from which China is never in sight. It is interesting to note (although the remark does not constitute proof of any kind) that Charon's orbit is just what would be expected if the object had originated as a chunk of Pluto, torn from the mother planet by some cosmic force.

The Christy-Harrington study also indicated that Pluto's axis must be nearly in the plane of its orbit around the sun. By contrast, the earth and other planets (except Uranus) spin on axes that are steeply inclined or even roughly perpendicular to their orbital planes. This means that once during each 248-year journey of Pluto around the sun, its axis points "north" toward the sun (that is, the sun is nearly directly above Pluto's north pole), and 124 years later, the planet's axis points "south" toward the sun, which then is nearly directly above Pluto's south pole. On the earth, there are only a few solar eclipses each year. On Pluto, there are no solar eclipses now nor will there be during the next few earth years, but beginning about 1983 and continuing for several years, Harrington told me, there will be a total eclipse of the sun every Plutonian day.

Charon is so close to Pluto (about twenty-two times closer than our moon is to us, as measured from lunar center to terrestrial center) that it appears enormous in Pluto's sky, eight times larger than our moon as seen from the earth. At least, this is so if the crude estimate made by Christy and Harrington of Charon's diameter—750 miles—turns out to be right. By contrast, the sun, as viewed from Pluto, looks tiny, about thirty to fifty times smaller (depending on Pluto's location in its orbit) than it does from the earth.

From the earth, the sun looks equally bright throughout the year (although instruments can detect a change when it is slightly closer or farther away). From Pluto, which moves in a noticeably elongated elliptical orbit, the sun is nearly three times as bright when seen from the planet's closest distance of approach (2.8 billion miles) as when Pluto is farthest (4.6 billion miles) away.

Not only the sun but also the orbits of the three innermost planets look small as seen from the vantage point of Pluto. As a result, during a central total eclipse, that is, when Charon's

center passes directly in front of the sun, Mercury, Venus, and the earth also are eclipsed. On the earth, we journey to the path of totality to view the spectacular solar corona during an eclipse of the sun. From Pluto, the corona might ordinarily be visible (if the brighter part of the sun did not dazzle the viewer's eyes) in the black, airless sky, just as the stars must be visible during the daytime. But the corona would not be seen at the midpoint of a solar eclipse, because then, like the sun itself, it would be wholly occulted. The best coronal views would come just after the beginning of an eclipse, as the edge of Charon passes across the tiny, bright sun and half of the corona is revealed; the other half would be seen along the opposite limb of Charon just before the eclipse ends.

Charon's orbit around Pluto is probably in the equatorial plane of the planet and hence is nearly perpendicular to the plane of Pluto's orbit around the sun. Twice during each 248-year orbital journey of the planet, when the sun is overhead on Pluto's equator, Charon is so oriented that it will go through a complete set of phases, new moon to crescent to full moon and back again, in one 6.4-day Plutonian month. At other times, however, there is no full phase cycle. For example, when the sun is overhead at the Plutonian north pole, Charon is a quarter-moon all month long.

To astronomers, the most basic parameter revealed by the observations of Charon is the mass of Pluto, which was determined from the rate at which Charon is moving in its roughly 22,000-mile-diameter orbit around the planet. The mass can be inferred from the speed because for a satellite circling at a given distance, the more massive the planet, the greater the gravitational force and hence the faster the satellite moves. Found in this way, Pluto's mass is far smaller than was previously estimated, amounting to only about $^1/_{630}$ the mass of the earth.

From the new findings, it appears that Pluto may be only 70 percent as dense as water; it would float if dropped into a big enough sea. Like the giant outer planets, it is made of lightweight stuff, not of rock and iron like the smaller, inner planets, including the earth and Mars. Pluto probably consists largely of frozen gases—methane and others.

The low value of Pluto's mass has an interesting historical consequence. Pluto itself was discovered by the American observer Clyde Tombaugh in February 1930, as a result of systematic photography of a broad region of the sky where it was predicted to lie. The prediction was based on the presence of small discrepancies between the calculated orbits of Uranus and Neptune and their actual observed motions. These discrepancies were attributed to the gravitational influence of an as yet unknown planet, and an idea of the likely location of the planet was inferred from the details of the orbital deviations.

Photographs of the region were made and more than two million faint stars were scrutinized until, finally, Pluto was found. But the new, much smaller value for Pluto's mass (once thought comparable to that of the earth, and estimated at $^1/_{10}$ that of the earth only a few years ago) cannot possibly correspond to the discrepancies in the orbits of Uranus and Neptune that were reported prior to 1930. The tiny planet, with only $^1/_{630}$ the earth's mass, is just too small to exert a detectable influence on its neighbors. Thus, the theory that predicted the existence and location of Pluto was wrong, even though the prediction was vindicated by the discovery of the planet near the indicated place. Some astronomers had suspected as much even before Charon was found and its orbit studied to determine Pluto's mass, but the results remove any lingering doubts. Pluto was discovered by hard work and some luck, not as a result of a great triumph of mathematical reasoning.

Since Pluto's orbit crosses that of Neptune, the suggestion was made that Pluto was an escaped moon of that planet. As a result of the analysis of Charon's motion, we now know that in terms of size and mass, Pluto is indeed more like a planetary satellite than a planet. Harrington and Thomas C. Van Flandern, a Naval Observatory astronomer known for imaginative theories of solar system dynamics, have reexamined that possibility. Harrington and Christy note that the same violent event, presumably a close encounter with an interloping planet, that disrupted Pluto's supposed orbit around Neptune could have raised an immense tide in Pluto, breaking it in two. The smaller piece would be Charon. The posited encounter would also have disturbed the orbits of Neptune's two surviving moons, Triton and Nereid. This would explain their present orbits, which are unusual among the satellites of the solar system. Nereid's path around Neptune is an ellipse more elongated than that of any other moon, while Triton is the only large inner satellite with an orbit that is either retrograde (one traversed in the opposite direction to the rotation of the planet) or noticeably tilted with respect to the planet's equator.

Harrington and Van Flandern calculate that their postulated interloping planet may have been two to five times as massive as the earth and have a present orbit about twice as large as that of Pluto. This theory must be regarded as informed speculation, but an unknown and possible tenth planet—Planet X—may yet be found at the farthest reaches of the solar system.

Astrophysicist Stephen P. Maran studies stars and nebulae. He is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

Celestial Events

by Thomas D. Nicholson

Sun and Moon On March 1, the sun is south of the equatorial plane in the constellation Aquarius and moves into Pisces on the 12th. On the 18th (in the mid-latitudes), the interval between sunrise and sunset is exactly 12 hours, although equinox (when day and night are of equal length) occurs several days later. The sun crosses the equator on the 21st or the 20th, depending on the time zone in which you live. It arrives at the vernal equinox and spring begins in the Northern Hemisphere on the 21st at 12:22 A.M., EST. But for those locations in the United States and Canada west of the EST time zone, spring begins on the 20th.

The moon begins and ends March as a slim crescent in the sunset sky. It remains an evening object through first-quarter on the 5th and full moon on the 13th. It enters the morning sky, rising after sunset and remaining later in the daytime, through last-quarter on March 21 and new moon on March 27. April phases are: first-quarter on the 4th, full on the 12th, last-quarter on the 19th, and new on the 26th. Apogee moon (farthest from the earth) occurs on March 10 and April 6; perigee (nearest the earth) on March 26 and April 22.

Stars and Planets Jupiter and Saturn are on the evening Star Map, both rising in the east or southeast early at night, near Regulus, the bright star of Leo. Jupiter is the brightest of the three objects, and Saturn (below Regulus) is next brightest. Mercury is also an evening star, low and well placed in the west after sundown during the first two weeks of March. In the morning sky, Saturn is in the west and Venus in the southeast, just rising as dawn breaks. Mars is also in the morning sky, but poorly placed for viewing. Uranus, Neptune, and Pluto are morning stars, as is Mercury after March 24.

March 1: Saturn is opposite the sun. Since it is now above the horizon at sundown, it becomes an evening star but is visible all night.

March 4–5: Aldebaran is near the moon tonight. The star is covered by the moon (an occultation) at about 2:00 A.M., EST, on the 5th, after they have set in North America, except in southern California, where the occultation can be observed.

March 7: Mercury is at greatest easterly elongation, to the left of the setting sun, and favorably located to be seen as an evening star, low in the west during twilight.

March 11–12: The moon is near Regulus on the night of the 11th; near Saturn on the 12th.

March 13: A partial lunar eclipse occurs over Europe, Africa, and parts of Asia. The eclipse ends before moonrise in North America, except over parts of New England and eastern Canada.

March 14: Mercury begins retrograde (westward) motion.

March 20 or 21: The sun is at the vernal equinox at 12:22 A.M., EST, on March 21, and spring then begins in the easternmost time zones of North America. It begins on the 20th elsewhere on the continent.

March 24: Mercury is at inferior conjunction (between earth and sun) and enters the morning sky.

March 25: The moon and Venus are very close this morning, in the southeast just after dawn. Jupiter resumes its direct (easterly) motion, toward the star Regulus.

April 5: Jupiter is near the moon tonight. Mercury resumes its direct (easterly) motion relative to the stars.

April 8: The bright object near the moon is Saturn. Regulus and Jupiter are to the right and higher than Saturn.

★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:20 P.M. on March 1; 10:25 P.M. on March 15; 9:25 P.M. on March 31; and 8:25 P.M. on April 15; but it can also be used for an hour before and after those times.


N
CEPHEUS
CASSIOPEIA
DRACO
LITTLE DIPPER
Polaris
CAMELOPARDALIS
PERSEUS
PLEIADES
Capella
AURIGA
BIG DIPPER
URSA MAJOR
April 1
March 5
GEMINI
TAURUS
Aldebaran
W
Castor
Pollux
April 4
Jupiter
Betelgeuse
ORION
Denebola
LEO
March 19
Regulus
Saturn
April 2
Rigel
March 13
Procyon
HYDRA
Alphard
Sirius
CANIS MAJOR
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Developing a Land Ethic

FOOTPRINTS ON THE PLANET: A SEARCH FOR AN ENVIRONMENTAL ETHIC, by Robert Cahn. *Universe Books, $10.95; 277 pp.*

The 1960s in America ended with an extraordinary degree of emotional concern for social issues: "environment," like "freedom," "peace," and various "liberations" boiled the decade's blood. More Americans than ever before in the nation's history became concerned about human–environment relations—what used to be called conservation. The result was a quasi-religious gospel of ecology. Powered by an environmental ethic, it produced demonstrations, a plethora of bumper stickers, and ringing editorials based on the premise that the world, or at least Lake Erie, was dying.

Robert Cahn asks, "So what?" He is interested in the *consequences* of the environmental hysteria. He wants to know what difference an ethical approach to environmental decisions made in the brass-tacks world of American life. If pragmatism is judging something by its practical results, then Cahn is consistently pragmatic. His attempts to discover what the environmental movement has accomplished have resulted in a book that specializes in specification rather than abstraction, in practice rather than theory. Not just a historian but an advocate, Cahn asks, "How can we develop new structures or types of institutional organizations through which environmental concerns can be raised and listened to at a high enough decision-making level to make a difference." Pragmatism.

The author was an original member, in 1970, of the President's Council on Environmental Quality. We learn of the Council's high hopes and their rapid deflation in the context of the Nixon administration. But the bulk of this partly autobiographical book is a series of interviews and short reports on practical efforts to implement concern for an ethical, not just an economic, relationship with the environment. As we might expect from a Pulitzer Prize-winning journalist, Cahn's approach in *Footprints on the Planet* is more journalistic than scholarly. The reading is exciting as Cahn explores the effects of laws requiring environmental-impact assessments, looks into private efforts to buy and preserve land, and visits experiments in alternative technologies and life styles. The book's promised specificity comes in finely drawn case studies, for example, the effort to save a tiny, endangered fish, the snail darter, from TVA's Tellico Dam.

Cahn's interests range widely. The environmental policies of General Motors and the Weyerhaeuser Company are the focus of two chapters, but we also learn about such small-scale efforts as Newell Mack's proposal of a Grandchild Rights Amendment to the Constitution.

Throughout his presentation Cahn asks, Where will the footprints left by man on the planet lead us? Is there hope for a meaningful penetration of environmental responsibility into American thought and action? There is, Cahn is frank to point out, a large segment of society that remains unpersuaded. Such people would agree with the loan and insurance company executive who, in response to Cahn's inquiry into his firm's concept of responsibility for environmental impact, said: "My sole responsibility is to the interests of the policyholders, investors in my company, and our employees. That responsibility is to make as high a return as possible on the investment." But Cahn also found that many companies take a much broader view of responsibility, based on a recognition that what they do affects people, the environment, and the future. They are prepared to look before they leap and to leap in such a way as to minimize the number and depth of their footprints on the earth. Government, law, and increasing citizen insistence are reinforcing this commitment. The environmental movement of the 1960s did not carry all before it. There was no revolution. But Cahn demonstrates convincingly that reform is clearly under way, and its cumulative impact may well be revolutionary.

From time to time the reader grows impatient with Cahn's repeated use of long block quotations drawn from his interviews. The journalist in Cahn also emerges in his tendency to report rather than to analyze, evaluate, and draw conclusions from his evidence. More sophisticated readers will not appreciate the cheerleading in the final chapter, which raises echoes of the Earth Day mentality Cahn purports to have transcended. Still, these are minor flaws in a book of great importance and unusual readability.

Roderick Nash is professor of history and environmental studies at the University of California, Santa Barbara.

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Additional Reading

Extraterrestrial Intelligence (p. 9)

Intelligent Life in the Universe, by I. S. Shklovskii and Carl Sagan (New York: Dell Publishing Co., 1968), a collaborative effort by two astrophysicists, Russian and American, offers a clear, detailed account of the astronomical, biological, and technological bases for the belief that intelligent life is a common occurrence in the universe. The book also includes discussions of the sociological, psychological, and political implications of extraterrestrial civilizations. Carl Sagan edited *Communication with Extraterrestrial Intelligence* (Cambridge: M.I.T. Press, 1973), a collection of papers, lectures, and recorded discussion sessions by internationally famous experts in such fields as astrophysics, mathematics, computer science, neurobiology, evolution, anthropology, and history. Another book on the subject is *Intelligence in the Universe*, by Roger A. Macgowan and F. I. Ordway (Englewood Cliffs: Prentice-Hall, Inc., 1966). "Extraterrestrial Intelligence: An Observational Approach," by B. Murray et al. (*Science*, February 3, 1978, pp. 485–92), states that current data processing and low noise reception technology would make possible the surveying of broad ranges of frequency and space for interstellar signals. The article discusses ways to carry out this research and the kinds of information it would reveal.

Skunk Cabbage (p. 42)

Although pictures of skunk cabbage have been published and some books devote a few paragraphs to the plant, not much has been written about this interesting member of the Araceae family. One article, "The Voodoo Lily," by B. J. D. Meeuse (*Scientific American*, July 1966, pp. 80–88), discusses the odor that attracts insect pollinators and the unusual metabolic pathways that generate heat in the skunk cabbage.

Fred Bruemmer

The Lapps (p. 48)

People of Eight Seasons, by Ernst Manker (New York: Crescent Books, 1972), is a large, well-illustrated book that covers the history, origins, and nomadic culture of the Lapps. *Turi's Book of Lappland* (Atlantic Highlands: Humanities Press, 1966) was written by Johan Turi, a Lapp wolf hunter. Turi describes "all the manners of his people's circumstances." The impact of snowmobiles on the Skolt Lapps of Finland, whose economy is based on reindeer herding, is discussed in *Technology and Social Change in the Arctic* (Menlo Park: Cummings Publishing Co., 1973). The author, Pertti J. Pelto, concludes that the present dependence of Lapps on outside sources of energy has resulted in social stratification and the mechanization of reindeer herding. The influence of the modern world on Lapps is also analyzed in Tim Ingold's *Skolt Lapps Today* (New York: Cambridge University Press, 1976), which covers Lapps of Finland and Norway and includes a bibliography and a guide to further reading. Israel Ruong, a native-born Lapp, is an expert in Lapp ethnology. His *The Lapps in Sweden* (Stockholm: Victor Pettersons Bokindustri, 1967) is a concise survey of major aspects of contemporary Lapp life. Most of the photos in *The Lapps*, by Bjorn Collinder (Westport: Greenwood Press, Inc., reprinted from 1949 ed.), were taken by Israel Ruong. "Norway's Reindeer Lapps," by Sally Anderson (*National Geographic*, December 1977), discusses Lapps' contacts with Norway's society, schools, and government.

Dolphins (p. 60)

Many books about porpoises and dolphins are more anecdotal than scientific. Kenneth Norris's *The Porpoise Watcher* (New York: W. W. Norton and Co., 1974), however, contains much information on porpoise behavior in the wild and in captivity. Karen Pryor, a dolphin trainer who worked with Kenneth Norris, gained much of

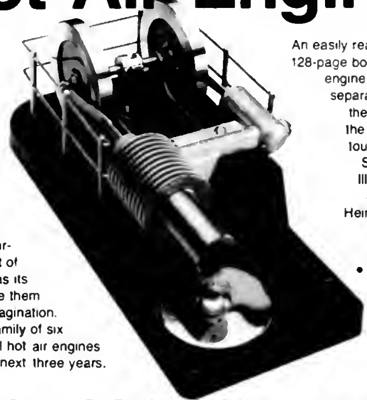
her experience in Sea Life Park in Hawaii. Her *Lads Before the Wind: Adventures in Porpoise Training* (New York: Harper and Row, Publishers, 1975) discusses the intelligence and social organization of captive and wild porpoises. *The World of the Bottlenosed Dolphin*, by David K. Caldwell and Melba C. Caldwell (New York: J. B. Lippincott Co., 1972), a general introduction with suggested readings, is part of the "Living World Books."

Prince Leopold Island (p. 68)

For more specific information, see D. N. Nettleship's "Studies of Seabirds at Prince Leopold Island and Vicinity, Northwest Territories: Preliminary Report of Biological Investigations" (Ottawa: Canadian Wildlife Service, Progress Note no. 73, 1977). Food preferences and foraging flights are discussed in "Patterns of Pelagic Distribution of Seabirds in Western Lancaster Sound and Barrow Strait, N.W.T." (Ottawa: Canadian Wildlife Service, Occasional Paper no. 39, 1978), by D. N. Nettleship and A. J. Gaston. A more general article is Nettleship's "Seabird Resources of Eastern Canada: Status, Problems, and Prospects," which can be found in the *Proceedings of the Symposium: Canada's Threatened Species and Habitats, 20–24 May 1976*, edited by T. Mosquin and C. Suchal and published by the Canadian Nature Federation as Special Publication no. 6 (Ottawa, 1977). More than 200 pages long, *The Fulmar*, by James Fisher (London: William Collins Sons and Co., 1952), is the key monograph on this species; published in 1952, it remains the most extensive and up-to-date study of the bird. The most detailed monograph on murres (260 pages) is Leslie M. Tuck's *The Murres* (Ottawa: Canadian Wildlife Service, 1960). For more references on sea birds, see the "Additional Reading" column of *Natural History*, February 1978. That issue also includes the article "Abundant Birds of Beringia," by H. Drury.

Katharine D'Agosta

Hot Air Engine



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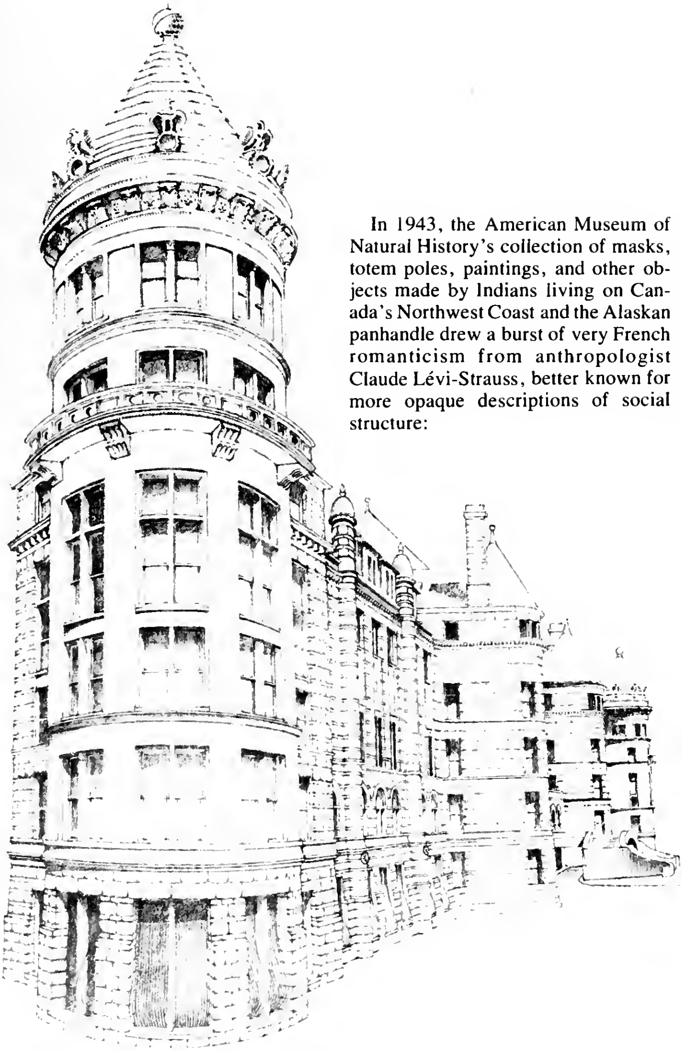

In 1943, the American Museum of Natural History's collection of masks, totem poles, paintings, and other objects made by Indians living on Canada's Northwest Coast and the Alaskan panhandle drew a burst of very French romanticism from anthropologist Claude Lévi-Strauss, better known for more opaque descriptions of social structure:

There is in New York a magic place where all the dreams of childhood hold a rendezvous, where century old tree trunks sing or speak, where indefinable objects lie in wait for the visitor with an anxious stare; where animals of superhuman gentleness press their uplifted little paws, clasped in prayer for the privilege of constructing for the chosen one the palace of the beaver, of guiding him into the realm of the seals, or of teaching him, with a mystic kiss the language of the frog and kingfisher.

One of the Museum's "animals of superhuman gentleness" is a carved beaver with uplifted paws, the last object in the catalog of **Objects of Bright Pride.** This exhibition of Northwest Coast art was jointly organized by the American Federation of Arts, which sponsors traveling exhibitions, and the Center for Inter-American Relations, whose purpose is to acquaint American audiences with art from other nations of the Western Hemisphere. Allen Wardwell, director of New York's Asia House Gallery, put together this show by selecting 100 objects from the Museum's extensive Northwest Coast collection.

Most of these masks, textiles, rattles, staffs, and other shamans' accou-

terments have never been displayed, except in the late nineteenth century when the Museum was sponsoring expeditions to Northwest Coast villages, whose inhabitants were already abandoning their traditional customs and ceremonies. Lévi-Strauss's enthusiasm for the aforementioned beaver was not misplaced. According to Wardwell, so extensive and so fine are the Museum's Northwest Coast holdings that "you could go through them tomorrow, select your own 100 favorite objects, and put together an equally fine exhibition."

In the catalog (on sale in the Museum Shop for $10.95, along with the exhibition's handsome poster, $6.00), Wardwell describes the history of the Museum collection and the personalities who assembled it. Like "Treasures of Tutankhamun" and the upcoming "Pompeii AD 79," "Objects of Bright Pride" displays a prosperous people's artistic and spiritual wealth. Thanks to the mild climate of the Canadian and Alaskan coasts and territories rich in fish and forests, the Haida, the Kwakiutl, the Tlingit, and other Northwest tribes of fishers and gatherers did

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not have to struggle to survive. But their chiefs were anxious to impress each other, and the people had an intricate mythology and many spirit protectors, symbolized by the raven, the bear, the wolf, the eagle, the frog—indeed, Wardwell says, "practically any animal that existed on the land or in the waters of the Northwest Coast, from mosquitoes to whales." Chiefs' prestige and shamans' powers were expressed in those symbols on totem poles, canoes, potlatch dishes, and shamans' masks. On the catalog's cover is a wolf mask that opens to reveal an eagle, so that a dancer, in the firelight of a high, shadowy feast house, could dramatically portray one animal-spirit after another.

Like most native Americans, Northwest Coast Indians no longer perform the ceremonies for which they created most of these "objects of bright pride." However, the flowing, curving lines of the beautiful pieces (Wardwell says that among the Kwakiutl, "some of the finest artists were also the best dancers and songwriters") inspire a desire to learn more about their makers. "Objects of Bright Pride" will be at the Denver Art Museum until March 18; later this year it will travel to the Los Angeles County Museum of Natural History and the Seattle Art Museum. In 1980, it will appear at the New Orleans Museum of Art and New York's Center for Inter-American Relations.

Museum Events

From Saturday, February 24, through Sunday, March 18, the **Paper Bag Players** will present eighteen performances of *Dandelion*, which the troupe calls "a fantasy based on Darwin's theory of evolution." This production represents a departure for the group, whose fast-moving musical revues, combining Donald Ashwander's lyrics and ragtimey music with props and costumes made of cardboard boxes, newspapers, and other odds and ends a child might find around the house, usually have contemporary themes and urban settings. In *Dandelion*, a hilarious history of the world, the still-molten earth is represented by a heaving paper garbage bag. The four actors use cutouts to describe such evolutionary watersheds as the first fish to leave the ocean, the development of the races, the invention of writing. Performances in the Auditorium will be at 1:00 and 3:00 P.M. on Saturdays and Sundays, and at 5:30 P.M. on Wednesdays, March 7 and 14. Tickets are $3.50, or $2.75 for Participating and Donor Members. Send your membership number and expiration date with a self-addressed, stamped envelope and a check made out to the Paper Bag Players, 50 Riverside Drive, New York, N.Y. 10024 (212) 362-0544. The Bags now sell records and playbooks of their productions and provide teachers with free study notes.

On Saturday, March 24, the American Littoral Society is sponsoring **Your Future in the Sea,** a symposium on ocean life, from 1:00 to 5:00 P.M. and from 8:00 to 11:00 P.M. in the Auditorium and Education Hall. The afternoon films and talks will cover large and dramatic topics, such as shipwrecks, as well as such smaller, overlooked subjects as the tiny freshwater fishes in New York's rivers and streams. Evening events include Stan Waterman's films of humpback whales and sharks, and filmmaker Robin Lehman's *Underwater in the Arctic.* Tickets, $3.50 for the afternoon, $5.00 for the evening, $7.00 all day, are available from the Membership Office (212) 873-1327.

"On a snowy Friday afternoon with the mask again stuffed into his pocket, Muhlbach marches through the doors of the Natural History museum and submits his request. The woman at the desk listens courteously, makes a telephone call and then informs him that Dr. Ekholm is occupied. However, Mr. Sanchez will look at the item.

"'Well, Mr. Sanchez may not be famous, but if he's associated with the museum he must be competent. All right, where do I find Mr. Sanchez?'"

Anyone who, like Muhlbach, hero of *The Connoisseur*, by novelist Evan S. Connell, Jr., wants to authenticate specimens or objects that may be of scientific value, can bring them to the Museum on **Identification Day**, Saturday, March 31. From 1:30 to 4:30 P.M., scientists from seven departments—*not* including Gordon Ekholm, the Anthropology Department's Mesoamerican specialist—will be available in the Rotunda to identify and discuss finds. There will also be a trash bin—unless the Paper Bag Players can be persuaded to leave a large bag—for those whose finds prove disappointments.

Pompeii AD 79 opens April 22. Members and the public can order tickets by calling the hotline (212) 999-7777.

Ann Marie Cunningham

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April 1979

American Museum of Natural History
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Cover: *Primavera, a wall painting, is modeled after one of the Graces and represents spring, female beauty, and flowers. It was discovered during excavations of a bedroom in a villa at Stabiae, near Pompeii, Italy. The painting is now in the National Archaeological Museum in Naples. Photograph from Scala, Editorial Photocolor Archives. A special supplement on Pompeii begins on page 37*

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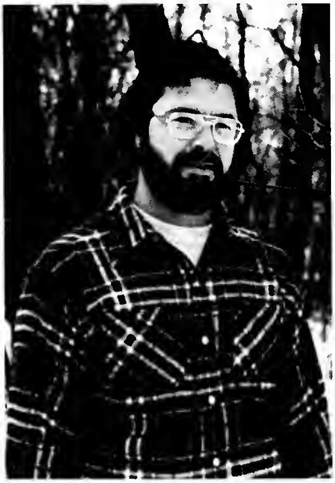
Authors

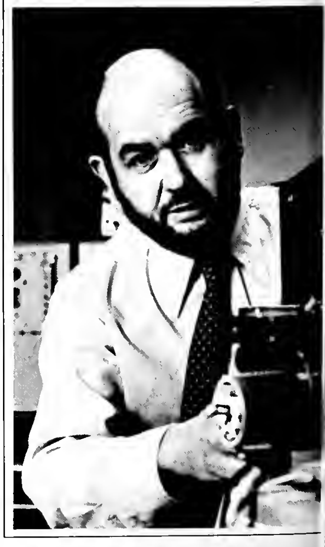
Frequently asked how he can stay up all night doing what he does, **Richard D. Howard** has a stock answer: "The activity is intense and exciting. Besides it is much too noisy." Howard studies mating bullfrogs, and the action usually doesn't begin until after 3:00 A.M. One of the things he does is look at a frog's lifetime reproductive success, then try to determine what factors may cause a variation. He is also interested in how age affects the type of mating strategy employed by males, that is, what behavior a young male uses to obtain mates while reducing the chance of injury from an older male. In looking for answers to these questions, Howard braves mosquitoes and dank nights on a pond in Michigan. His diurnal activities include being an assistant professor at Bowling Green State University in Ohio.



Walter Rosenblum

Blanche R. Brown has long been fascinated by Greek and Roman painting. She took her first graduate art history course in it, wrote her first term paper on it, and devoted her master's thesis and doctoral dissertation to aspects of it. "The first job I got after my master's was to write a book on Greek and Roman painting in American collections, which never appeared because the publishing program it was to be part of fell apart. But that project and others afterward have taken me repeatedly to Pompeii." Brown subsequently became a lecturer in the adult education program at the Metropolitan Museum of Art, and is now professor of art history at New York University. Besides various scholarly publications, she is the author of *Five Cities: Art Guides to Athens, Rome, Florence, Paris, and London*, published by Doubleday in 1965. When "Pompeii AD 79" was still at the Boston Museum of Fine Arts, Brown described the forthcoming show for New York art lovers and classics buffs in the *New York Times Sunday Magazine* ("Out of the Ashes: Glowing Treasures of Pompeii," April 23, 1978).

Martin Prinz, chairman of th Department of Mineral Sciences at th American Museum of Natural History worked on the "Volcano!" show which will open at the Museum wit the "Pompeii AD 79" exhibition o April 22. Prior to his involvemer with "Volcano!" Prinz had wi nessed the volcanic eruptions th tourists can see in Hawaii and ha studied volcanic and deep-seate rocks from the earth and moon an asteroids as represented by meteorites Once, when Prinz was in the field i American Falls, Idaho, a spelunke offered to show him a rift that he ha discovered in the Snake River Plair near Craters of the Moon Nation Monument. At the wide crack in th plain, Prinz could look down and se the evidence of "volcanic processe at work. On the walls, lavas ha gushed up and dripped down agair I felt as though I were looking dow inside the planet as in a Jules Vern novel." The rift's discoverer called Crystal Ice Caves, and today visitor can see for themselves what Prinz wa among the first to see.



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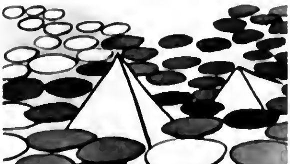

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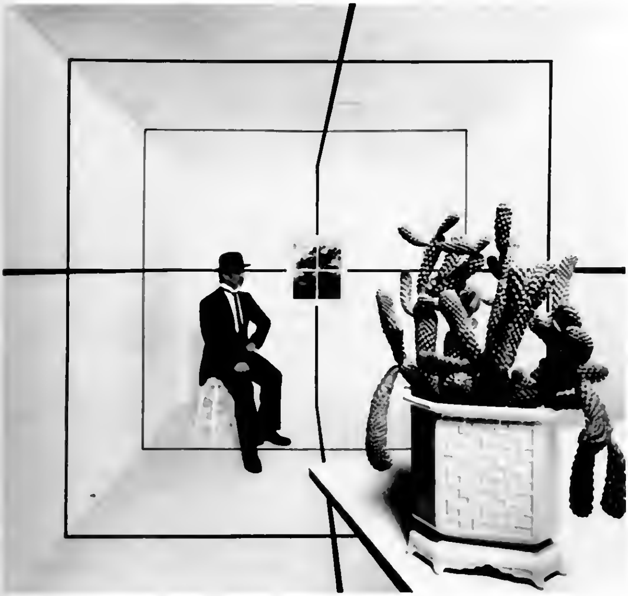
1979 *See *Popular Science* Jan. 1979

"My enthusiasm for Pompeii goes back thirty years," writes **L. Richardson, jr.** "It began at the American Academy in Rome with the discovery that the most famous archeological excavation in the world was still a hotbed of unanswered questions." The Academy awards fellowships in the creative arts and classical studies to artists and scholars from the United States. Richardson, who is a trustee of the American Academy and a member of the jury that awards fellowships to classicists, credits the Academy with shaping his scholarly interests. Now James B. Duke Professor of Latin at Duke University in Durham, North Carolina, Richardson has published a number of articles on Pompeian subjects and is at present working on an architectural history of the city. His next project is a new topographical dictionary of ancient Rome.

After a sojourn at the American Academy in Rome, **James Packer** recently returned to Northwestern University, where he is associate professor of classics. His studies of Roman civilization have concentrated on its architecture—notably Rome's Basilica Ulpia and Pompeii's lower-class housing. He has constructed detailed plaster models of architecture from all periods, particularly of the classical and Victorian eras. One of Packer's current activities is a study of New York City's cast iron buildings—"the façades are ideal for plaster models"—and he is writing a technical guide for the construction of architectural models in plaster. This work is based on techniques collected and devised by Pierino Di Carlo, the recently retired craftsman who devoted forty years (1933 to 1973) to building the model of ancient Rome in that city's Museo della Civiltá Romana.

Weekly hikes with his father through the environs of his native Stettin, Germany, were the genesis of **Hartmut Walter**'s curiosity about birds, which eventually led to his extensive study of Eleonora's falcon. The thousands of hours that he devoted to observing the raptor named after a fourteenth-century woman were spent among the inhospitable rocks of Paximada in the Mediterranean Sea. Now an associate professor in the Department of Geography of the University of California at Los Angeles, Walter will next venture into the field to research the sooty falcon in Oman. True to his European upbringing, one of his avocational passions is soccer. In the photograph, Walter (at left) discusses the work at hand with a British ornithologist and Royal Air Force officers prior to an aerial census of Eleonora's falcon on Cyprus.

On Owning the Camera That Could Take This Ordinary Photograph



EXAMINE this photograph through a powerful magnifying glass and you will see that there is...nothing unusual.

But there should be.

A clue: the room was recorded by an extreme-wide-angle lens—the equivalent of a 21mm lens on a 35mm camera. So the vertical lines at the edges of the room should be bending inwards at the top and bottom. *Yet they are perfectly straight.*

The horizontal lines should also be bending. They are straight.

The vase in the foreground should be distorted. It isn't.

A most unusual camera has been at work here.

A rare lens.

The camera is a Hasselblad SWC, or Super Wide C. The lens is a 38mm Zeiss Biogon *f*4.5. It is permanently affixed to the camera body.

Unlike most other wide-angle lenses, the Biogon is not a retrofocus design. It is a *true* wide-angle lens, uncompromisingly designed to scan a 90° diagonal angle of view with virtually no optical distortion.

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It tells the truth.

Like all Hasselblad cameras, the SWC is actually many cameras.

Because it sees as the human eye does—accurately and without distortion—it is an almost indispensable tool for the architectural and industrial photographer who must have realism at all costs.

It is a magnificent landscape camera. Consider its startling depth of field. The vase in the photograph is exactly 26 inches from the film plane. At *f*22, everything outside the window, as far as the eye can see, is also in focus. Vast, sweeping panoramas can be created that are in immaculate focus from within arm's reach to far horizon.

The SWC is also prized by press and sports photographers. The enormous depth of field makes constant changes of focus quite unnecessary. The between-lens leaf shutter is fully synchronized for every type of flash at every speed up to 1/500 of a second. And the cropping possibilities are almost limitless, since each frame of film is 2¼ inches square, *almost four times the area* of a 35mm frame. (See box below for actual size.)

A prodigious system.

At this point, you have only *begun* to learn the potential of this awesome instrument. There are backs, for instance, that give you a choice of 12, 16, 24, or 70 exposures. Backs that transform the SWC into a 6 x 4.5cm camera. Or a 4.5 x 4.5cm camera for superslides that can be shown in any 35mm projector.

A lavish brochure on the SWC and other Hasselblad cameras—plus an actual 8 x 8 enlargement of the photograph on this page—is available free if you write: Braun North America, Dept. NH4H , 55 Cambridge Parkway, Cambridge, Mass 02142—a division of The Gillette Company and exclusive marketer of Hasselblad in the U.S

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The Pasqueflower

"The chance to find [one]," wrote Aldo Leopold, "is a right as inalienable as free speech"

Earliest among the rites of the western spring is the blossoming of the pasqueflower, which, like the eastern arbutus, precedes by a month the rest of the vernal flora. Its precocious beauty accounts for its name, a flower of the *Pasque*, Easter; and its loveliness, size, and season led Aldo Leopold to introduce his *Sand County Almanac* with the plea that "the chance to find a pasqueflower is a right as inalienable as free speech." Recently, just after the equinox, hiking a meadow in the foothills of the Rockies, I delighted in thousands in finest bloom, with nothing else out save the aspen catkins.

Its finding is a joy immediately in the aesthetic encounter, but beyond that, this windflower is a cherished symbol of the wild for reasons that run deeper. In its annual renewal as the first spirited flowering against the blasts of winter, it is a sign against the eternal storm. Like the daffodil in Shakespeare's England, the pasqueflower dares to "take the winds of March with beauty," and such a brave flower can help us ponder what it means to live in and against the wild. So I venture here to let the meeting of it take a philosophical turn.

Winter in the Rockies is too much a still and lifeless scene, save for, or yet more truly because of, the howling wind. The beauty is of icy peaks, glistening snowfields, crystalline flakes, gaunt aspen, the somber hues of lichens on weathered granite. The seasonal green is gone, and only the conifers preserve it with dark coolness, their branches pruned back by the weight of the snows. Winter is all of frozen beauty, Mother Nature hibernates; by the time of the equinox we tire and hope for the "spring" of life.

The pasqueflower symbolizes all that is missing in the wintry landscape, and should there come a spring without the regeneration it prefigures, the winter would have grown lethal. Wildness without its flora would be only the bleak and conquering storm, and it is this florescence that the pasqueflower helps us to celebrate because it dares to bloom when the winter of which we have wearied is not yet gone. "Flowering" touches values so soon;

Animals, Animals

by Holmes Rolston III

this biological phenomenon becomes a metaphor for all the striving toward fruition that characterizes the psychological, intellectual, cultural, and even the spiritual levels of life.

Flowering adds the splendor of art to our often rather more mean thoughts concerning the evolution of life, for the flowers in the jungle fit their bearers for survival and yet also reveal how life pushes toward a level of living beauty that exceeds all precedent in the nonflowering wilderness. We love the landscape, the sunset, the night sky; yet greatly exceeding the geophysical, mineralogical, and celestial ranges of beauty are those of the emergent structures of life, particularly as these come to their botanical apogee in the flowers of the higher plants, which so marvelously combine function and beauty, as though to mark life's reproduction with a special sign.

Other plants flower more simply, as with the hundred thousand aspen catkins that I passed with the thousands of pasqueflowers, but even these wind-pollinated flowers or the ferns and mosses, which do not properly flower at all, still bear reproductive structures that, when looked at more nearly, amply enrich the phenomenon of florescence. Flowering, whether great or small, is a many-splendored thing, circling round the pageant of life that perennially springs from the latent earth.

The brilliance of this pasqueflower has its simplest explanations in mechanisms for flowering so soon at the winter's end. It must have petals (or, as the botanists prefer, petallike sepals) large enough to attract the few insects that are out so early. The downy surface of transparent hairs on its palmate leaves and stem insulates and also, as do those of the pussy willows, allows a radiation heating to temperatures high enough for development, providing a miniature greenhouse effect. The same coat probably also protects the pasqueflower from unneeded radiation, although it needs much light and cannot grow in the shade, and the hairs n its water economy.

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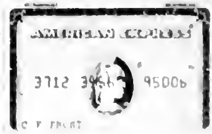

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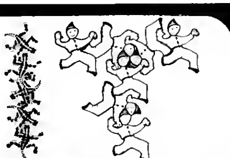

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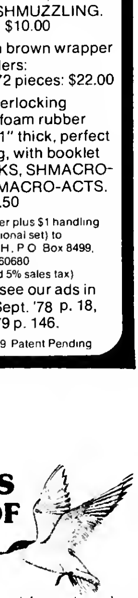

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The energy stored in its root system is drawn upon for its spring growth, and the hollow stem seems to permit its rapid growth and to allow both its bending before the wind and a turning of its floral head to face the spring sun. By the last adaptation it gains enough solar energy to keep the floral parts operating efficiently. Its sap has a low freezing point, and all its parts are soaked with an acrid irritant, which discourages foraging deer and elk. This rose has its poison thorns.

This is survival through winter, to be sure, but the pasqueflower helps me to glimpse something more, the skill of art superimposed on the science of survival. This is exuberance in the fundamental, etymological sense of being more than expectedly luxuriant. Does not such an encouraging beauty speak of that face of nature that overleaps the merest hanging on to life to bear the winds of the storm with vigorous, adorning beauty? Nor is it just the grand petals of delicate purple whorled about the yellow stamens and pistils, for the fingered involucre frames the flower so well, and the villous coat has a sheen that, seen backlighted by the sun, gives a lustrous aura to complement the gentle leafy green.

Butterflies drink its nectar, and if I first reduce them to their pollinating function, I notice soon after their winged beauty. The bees come too, and I must look more closely again, to find in their wing venation still further evidence of the art that emerges with the architecture of life. As when we strip the beauty from the melodies of birds in spring or from human romantic love, laying bare only biochemical reproductive functions, so too here, perhaps when the more is reduced to the less, we refuse to let life's production and rebirth become a window into life's spirited inventiveness. But when released so, what images indeed can the flower build in the mind!

The flower gave our race its first glimpses of paradise, in the Persian walled garden from which the term derives. Flowers hint of Eden to those who deeply appreciate them; but earth is a natural garden, not entirely, not in winter, but exuberantly enough in spring and summer that its flowering recalls how life persists with appealing grace through the besetting storm. In the legendary days of Noah, the Hebrews took the rainbow for a sign after the Flood that life would not ever be destroyed but would survive its tragedies in blessedness.

The pasqueflower, too, when it bursts forth with the breaking up of the raging winter, is such a reminder of life's survival, indeed of a prospering such that it hopes for paradise. After the flood, the winter, this earth will always come round again to its garden season, to bring us somehow nearer to its ultimate natural significance, even to the sacred character of life in its struggling beauty. We begin to see why it is so inalienable a right to be able to find in the dusty earth this draft of beauty.

The natural character that we now celebrate comes through even its scientific name, *Pulsatilla patens*. It is "shaken" (*pulsatus*) by the incessant winds, and of diminutive form (*-illa*), while yet "spreading broadly" (*patens*) its brandished petals. John Gerard wrote in his 1597 *Herbal* that the "passe floure is called commonly in Latine *Pulsatilla*." Botanists have often placed *Pulsatilla* in the genus *Anemone*, that genus going back to the Greek word for "windflower," but most prefer to separate it out owing to the tails of the achenes, which become so greatly elongated as it sows those villous seeds on the very winds that blast it. Those wisps rising over the prairie gave it another name—the prairie smoke.

The winds have carried it virtually around the north temperate world, for it is found in northern Europe, in the western two-thirds of North America, and in the Siberian Orient. Further, from some ancestral plant there have evolved several closely related species. *Pulsatilla* is everywhere a flower that comes on the heels of winter and is without peer in its own environment. No other flower is able so to endure the cold and, if need be, the dry, and to spread its petals forth so boldly from the plains through the montane and into the alpine. Its taxonomy, geography, and ecology all return us to its hardy capacity to prosper before the wind and the winter.

The popular name further employs this character, for its prevenient grace has drawn it into association with Easter and the Passover, recalling in Christianity and Judaism alike the passing out of bondage, the passing by of death, and a release into freedom and newness of life. Gerard continues, "They floure for the most part about Easter, which hath mooved mee to name it *Pasque floure*." But long before, it was known in Old English as *passefloure* and in French as

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passefleur, *passe* being but a half-translated form of Pasch, going back through the Greek *pascha* to the Hebrew *pesach*.

Whatever its antiquity, we might first think, that association has no natural basis; it is entirely fictional. But we later find connections that are so fundamental—biologically, psychologically, and even theologically—that we are hardly aware of them. It is no coincidence that Easter comes with the spring; the energies of Easter belong with the energies of spring. The vernal lily is more than an artificial symbol, it is a natural emblem of life springing up anew out of a wintry death, and so too with those other symbols of life's reproductive powers—lambs, eggs, rabbits, and even the ladies parading in their fetching dresses and bonnets—that sometimes seem so flippant beside the sobriety of the grave and the hope for more.

The death of Jesus was not incidentally at the Passover, and centuries later, the missionary church, moved by forces it did not wholly understand, superimposed its annual memorial of the new covenant onto the "pagan" rites of spring that preceded Christianity in Europe. Easter is from an Indo-European root for the East, the rising sun, and the beloved Teutonic goddess Eostre, whose holiday was celebrated at the equinox. By a related insight, hardly less profound or subliminal, the church matched its incarnation with the winter solstice and the pagan rejoicing that the sun would begin its return toward spring, this coinciding with the birth of a Savior.

Jim Brandenburg

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Whatever meaning the conquering faith added did not so much replace as complement, enrich, and extend the primitive and universal impulse in us to celebrate the return of the warmth of spring and the resurgence of life that is given by these mysterious powers of the sun. The Hebrew Passover, also with its lambs and eggs, was earlier transposed from a "pagan" pastoral festival as a coming out of bondage in Egypt blended with a deliverance from the grip of winter.

Perhaps it may not be so fanciful but rather entirely realistic that this pasqueflower should in its limited and natural way come to serve as a symbol for what Jesus in his unlimited, supernatural way represents to the Christian mind, a hint of the release of life from the powers that would suppress it. The pasqueflower is of a piece with the rose of Sharon, which blooms in the desert, and the shoot budding out of the stump of Jesse, for here we have an earthen gesture of the powers of resurgent life.

We have become too wise in our own conceits if ever we let a winter solstice go by without a glance upward to rejoice that the sun will sink no lower in the darkening sky, glad that the shadows will not lengthen, glad that the longest night is done. We have become too artificially cultured if ever we let a vernal equinox fail to bring hope in the spring it pledges, glad that there is more of the day than of the night, more of life and less of death. We walk too hurriedly if ever we pass the season's first pasqueflower by, too busy to let its meeting stay us for a quiet moment before this token of the covenant of life to continue in beauty despite the storm. We come too sadly to the autumnal equinox if ever there comes a fall without its thanksgiving, making us glad for the harvest, which, remembering how there is in every root and seed a hope, makes us brave before the returning winter.

Flowers cover our every grave. But is that because they mask death for a moment, before they too fade, their comfort only an illusion adorning death? I think not. They belong there because they somehow betoken to us, at levels more subconscious than we know, this florescence of life, this capacity of the germ plasm to pass through death, to persist in transient beauty over the vortex of chaos.

In one of the earliest burials known to archeology, in the Shanidar cave in northern Iraq, there lay a man who was congenitally deformed, his bones amidst fossil pollen. His Neanderthal mourners had gathered grape hyacinths and bachelor's buttons, hollyhocks and golden ragwort, and covered him with a blanket of blossoms. They cared for this cripple in life, and then found at death no better symbol than a floral tribute to communicate their hope that life would envelop death.

Their passions at that grave almost make us weep, for they touch so anciently this hope for the "passing over" of death by life, a force that reaches on to the pagan Germanic Easter, on to the Semitic exodus out of winter and Egypt, on to Calvary, on to the medieval naming of the pasqueflower, and on to beset me now.

If the flower has for fifty thousand years served as an emblem of resolution in the face of death, then my thoughts run steady in a natural track as perennial as the springs since Neanderthal times. The flower is a very powerful symbol, it has had a psychologically elevating effect in every culture, and if anyone cares to say that this is not scientific, but romantic, that does not make it any less real. Our recent "flower children" knew this impact when they hung flowers in protest in the guns of destruction.

For longer than we can ever remember flowers have been flung up to argue against the forces of violence and death, because that is what they do in and of themselves, and thus they serve as so ready a sign for any who encounter them in a pensive mood, wearied of the winter, frightened by the storm, saddened by death. This is why it is liberating to find the pasque-

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flower bearing with beauty the winds of March.

The beauties of winter are heartless, yet there is no deeper mystery than how life flowers because of the agonies that threaten it. Environmental pressures shape life—that is the premise of all biological science. Life is pressed by the storms, but it is pressed on by the storms, and environmental necessity is the mother of invention in life. The winter is a sinister maelstrom against which we fling out our curses, against which we fling up our flowers, yet is it chaos and otherness and nothing more? Or does it too belong in the seasonal economy, as night complements day, almost a sign of the unfathomable dialectic of life with its opposite?

Flowers arose against the adversities of the drought and the cold. We can only speculate about their origins, but it is axiomatic within evolutionary theory that the advanced flowers of the angiosperms conveyed some advantage, perhaps the exploitation of insects for better outbreeding, more experimentation for altered forms, such as the encased seed or the herbaceous habit, the better adapted against the dry or the cold. The seasonal tropical desert was perhaps more significant than the winter in the beginning, but each harshness has much in common, and the subsequent global advance of the angiosperms amply proved their effectiveness for overwintering.

The feat of flowering in the spring is a reciprocal of the defeat of the "fall," and the floral diversification of our temperate climates is very much a product of winters alternating with summers. This pasqueflower springs forth in its particular form of early beauty as much because of the winter as to spite it; it buds and blossoms because it is blasted. Without the wind, there would be no windflowers, and without the advancing of death, there is no advancing of life.

Modern man came out of the Ice Age. Perhaps as the human genetic stock was exposed to the pressures of glaciation, relaxed in the interglacial ages, like winters and summers, we were made modern in this recent flowering of Indo-European civilization. The north wind made not only the Vikings, it made us all. We do not owe every culture to the Pleistocene winter, for archaic civilizations arose in the tropics, but we owe all culture to the hostility of nature, provided only that we can keep in tension with this the support of nature that is truer still, the one the warp, the other the woof, in the weaving of what we have become.

Beyond that, all who live where the pasqueflower flourishes will, when they have searched deeply, find how it was the cold that made our ancestors sew garments and build fires, how it made them fashion an ever more insulating culture, in which dress we proved able not only to survive but to flourish. Our human genus flowered before the winter, much as does this pasqueflower; and once again we find the arts in their beauty superimposed on the science of survival.

This pasqueflower endures the winter in noble beauty; but its suffering is not only the shadow of its beauty, it is among the roots that nourish it. That "suffering" is metaphorical for this insentient flower; still, this natural character is an apt sign to be drawn into association with the passion of Easter and the Pesach. Life decomposes and out of its throes it recomposes; it persists in perpetual beauty while it is perpetually perishing.

The way of nature is, in this deep though earthen sense, the Way of the Cross. Light shines in the darkness that does not overcome it. This noble flower is a poignant sacrament of this, and to chance to find it in earliest spring, and to pause at that meeting, is to find a moment of truth, a moment of memory and promise. Let winters come, life will flower on as long as earth shall last.

Holmes Rolston III teaches philosophy and environmental ethics at Colorado State University in Fort Collins.

E R Degginger

Since you have to pay the penalty for being in your bracket,
you might as well get some of the rewards.

Time's Vastness

The impact of 1/200,000 second per year is nothing to us, but tremendous for life and the earth

I will never forget Toscanini's last concert—the night that the greatest maestro of them all, the man who held all Western music in his infallible memory, faltered for a few seconds and lost his place. If heroes were truly invulnerable, how could they compel our interest? Siegfried must have a mortal shoulder, Achilles a heel, Superman kryptonite.

Karl Marx remarked that all historical events occur twice, first as tragedy, the second time as farce. If Toscanini's lapse was tragic (in the heroic sense), then I witnessed the farce at the start of this year. I listened while the ghost of Guy Lombardo missed a beat. For the first time in God only knows how many years, that smooth sound, that comfortable welcome to the New Year, fell apart for a mysterious moment. As I learned later, someone forgot to tell Guy about the special 61-second minute that ended 1978; he started too early and could not compensate with unnoticed grace.

This second, added for internal bookkeeping to synchronize atomic and astronomical clocks, received wide press coverage, virtually all of it in a jocular vein. And why not—good news is rare enough these days. Most reports pushed the same theme: they twitted scientists about their concern for consummate accuracy. After all, how can so trifling a span of time as a single second matter?

I then remembered another figure, 1/200,000 second per year. This figure, an ant before the behemoth of a full second, is the annual rate of deceleration in the earth's rotation due to tidal friction. I will attempt to show just how important such a number can be in the fullness of geologic time.

We have known for a long time that the earth is slowing down. Edmund Halley, godfather to the famous comet and Astronomer Royal of England early in the eighteenth century, noted a systematic discrepancy between the recorded position of ancient eclipses and their predicted areas of visibility based on the earth's rate of rotation in his time. He calculated that this disparity could be resolved by assuming a faster rotation in the past. His data have been refined and reanalyzed many times, and eclipse records suggest an approximate rate of two milliseconds per century for rotational slowing during the past few thousand years.

Halley proposed no adequate reason for this deceleration. Immanuel Kant, a versatile fellow indeed, supplied the correct explanation later in the eighteenth century. Kant implicated the moon and argued that tidal friction had slowed the earth down. The moon pulls the waters of the earth toward it in a tidal bulge. This bulge remains oriented toward the moon as the earth rotates under it. From our point of view as earthbound observers, high tide moves steadily westward around the earth. This tide, moving continuously across land and sea (for continents have their minor tides as well), creates a great deal of friction. Astronomers Robert Jastrow and M. H. Thompson write: "A huge quantity of energy is dissipated in this friction each day. If the energy could be recovered for useful purposes, it would be sufficient to supply the electrical power requirements of the entire world several times over. The energy is actually dissipated in the turbulence of coastal waters plus a small degree of heating of the rocks in the crust of the earth."

But tidal friction has another effect, virtually invisible on the scale of our lives but a major factor in the earth's history. It acts as a brake upon the spinning earth, slowing the earth's rotation at the leisurely rate of about two milliseconds per century, or 1/200,000 second per year.

Braking by tidal friction has two correlated and intriguing effects. First, the number of days in the year should be decreasing through time. The length of the year seems to be essentially constant relative to the official cesium clock. Its invariance is affirmed both empirically, by astronomical measurement, and theoretically. We might predict that the solar tide should slow the earth's revolution just as the lunar tide slows its rotation. But solar tides are quite weak, and the earth, hurtling through space, has such an enormous moment of inertia that the year increases by about three seconds per billion years. Here we finally have a figure that we can safely ignore—half a minute from the origin of the earth to its destruction by an exploding sun some five billion years hence!

Second, as the earth loses angular momentum in slowing down, the moon—obedient to the law of conservation of angular momentum for the earth–moon system—must pick up what the earth loses. The moon does this by revolving around the earth at a greater and greater distance. In other words, the moon has been steadily receding from the earth.

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If the moon looks big now, low on the horizon on a crisp October night, you should have been around to see what the trilobites saw 550 million years ago. G. H. Darwin, noted astronomer and second son of Charles, first developed this idea of lunar recession. He believed that the moon had been wrenched from the Pacific Ocean, and he extrapolated the present rate of recession back to determine the time of this convulsive birth. (It does fit, but thanks to plate tectonics, we now know that the Pacific is not a permanent hole, but a configuration for the moment.)

In short, tidal friction induced by the moon has two necessarily coupled consequences through time: slowing of the earth's rotation to decrease the number of days per year, and increasing the distance between earth and moon.

Astronomers have long known about these phenomena in theory, and they have measured them directly over geologic microseconds. But until recently, no one has known how to gauge their effects over long stretches of geologic time. A simple backward extrapolation of the current rate will not work because the intensity of braking depends upon the configuration of continents and oceans. The most effective braking occurs when tides sweep across shallow seas; the least effective when tides move with comparatively little friction over deep oceans and land. Shallow seas are not prominent features of our present earth, but they covered millions of square miles at various times in the past. The rapid rates of these times may be matched by very slow deceleration at other times, particularly when all the continents coalesced into a single Pangaea. The pattern of rotational slowing through time therefore becomes more a geologic than an astronomical problem.

And I am delighted to report that my own brand of geology has yielded, albeit ambiguously, the required information—for some fossils record in their patterns of growth the astronomical rhythms of ancient times. The haughty and high-riding mathematicians and experimentalists of modern geophysics do not often take a bow toward a lowly fossil. Yet one prominent student of the earth's rotation has written: "It appears that paleontology comes to the rescue of the geophysicist."

For more than a hundred years, paleontologists had occasionally noted regularly spaced growth lines on some of their fossils. Some had suggested that they might reflect astronomical periodicities of days, months, or years—much like tree rings. Yet no one had done anything with these observations. Throughout the 1930s Ting Ying Ma, a somewhat visionary, highly speculative, but infallibly interesting Chinese paleontologist, studied annual bands in fossil corals to determine the position of ancient equators. (Corals living at the equator in regimes of nearly constant temperature should not show the seasonal bands; the higher the latitude, the stronger the bands.) But no one had studied the very fine laminations that often occur by the hundreds per band.

In the early 1960s, Cornell paleontologist John West Wells realized that these very fine striations might record days (slow growth at night versus faster growth during daylight, much as trees produce annual bands by the contrast between slow winter and rapid summer growth). He studied a modern coral with both coarse (presumably annual) and very fine banding, and he counted an average of about 360 fine lines to each coarse one. He concluded that the fine bands are daily.

Wells then searched his collection for fossil corals sufficiently well preserved to retain all the fine bands. The very few he found enabled him to make one of the most interesting and important observations in the history of paleontology: a group of corals about 370 million years old had an average of just under 400 fine bands per coarse band. These corals had witnessed a year of nearly 400 days in their time. Direct, geologic evidence had finally been found for an old astronomical theory.

But Wells's corals had affirmed only half the story—increasing length of day. The other half, recession of the moon, required fossils with daily and monthly banding; for if the moon had been much closer in the past, it would have revolved around the earth in a much shorter time than it does today. The ancient lunar month should have contained fewer than the 29.53 solar days in the present month.

Since Wells published his famous paper on "Coral Growth and Geochronometry" in 1963, several claims have been entered for lunar periodicities as well. Most recently, Peter Kahn, a paleontologist from Princeton, and Stephen Pompea, a physicist from Colorado State University, have argued that the key to lunar history lies with one of everybody's favorite creatures, the chambered nautilus (*Nature*,

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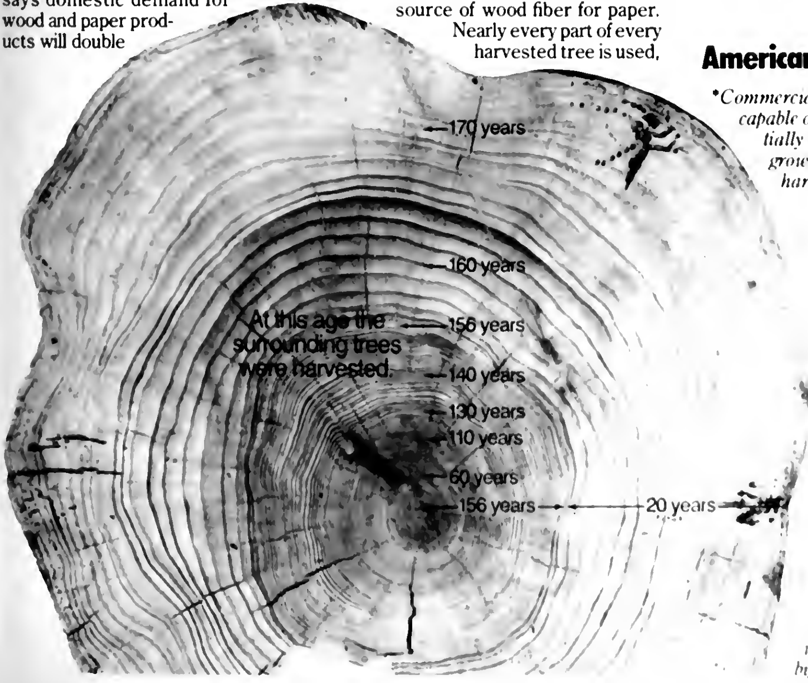

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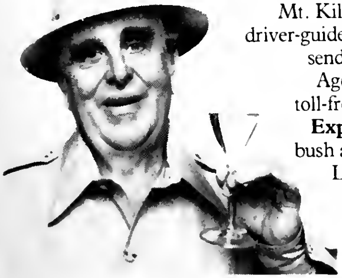

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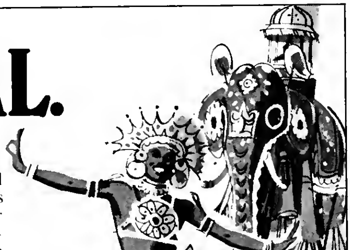

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Pearl of the Indian Ocean

October 19, 1978). The nautilus shell is divided into very regular internal partitions called septa. These same septa, and the beauty of their construction, inspired Oliver Wendell Holmes to exhort us, by analogy, to do better with our internal lives:

> Build thee more stately mansions, O
> my soul,
> As the swift seasons roll!
> Leave thy low-vaulted past!
> Let each new temple, nobler than
> the last,
> Shut thee from heaven with a dome
> more vast,
> Till thou at length art free,
> Leaving thine outgrown shell by
> life's unresting sea!

I am happy to report that nautiloid septa may have extended their utility beyond Holmes's musings on immortality and O'Neill's cribbing of a title for a play. For Kahn and Pompea counted the finer growth lines on the exterior of *Nautilus*'s shell and found that each chamber (the space between successive septa) contains an average of thirty fine lines, with little variation either among shells or on successive chambers of single shells. Since *Nautilus*, living in deep Pacific waters, migrates daily in response to the solar cycle (it moves into shallow waters at night), Kahn and Pompea suggest that the fine lines record days. The secretion of septa may be entrained to a lunar cycle. Many animals, including humans of course, have lunar cycles, usually tied to breeding.

Nautiloids are quite common as fossils (the modern chambered nautilus is the sole survivor of a very diverse group). Kahn and Pompea counted lines per chamber in twenty-five nautiloids ranging in age from 25 to 420 million years old. They argue for a regular decrease in lines per chamber from thirty today, to about twenty-five for the youngest fossils, to only nine or so for the oldest. If the moon circled the earth in only nine solar days 420 million years ago (when the day only contained twenty-one hours), then it must have been much closer. Cranking through some equations, Kahn and Pompea conclude that these ancient nautiloids saw a gigantic moon slightly more than two-fifths its current distance from the earth (yes, they had eyes).

At this point, I must confess to some ambivalence about this large body of data on fossil growth rhythms (an unease that explains why I have avoided this exciting subject for five years of

these columns, even though, as a paleontologist, I love to tout my profession). The methods are beset with unsolved problems. How do you know what periodicity the lines reflect? Take the case of fine lines, for example. They are usually counted as though they record solar days, but suppose they are a response to tidal cycles—a periodicity that involves both the earth's rotation and the moon's revolution. If the moon revolved in a much shorter time in the past, then ancient tidal cycles were not nearly so close to the solar day as they are now. (You should now grasp the importance of Kahn and Pompea's argument, made without direct evidence by the way, that the fine lines of *Nautilus* reflect day–night cycles of vertical migration rather than tidal effects. In fact, they explain their three exceptional cases by arguing that these nautiloids inhabited persistently shallow, nearshore waters and may have recorded the tides.)

Even if lines are a response to solar cycles, how do you assess the days per ancient month or year? Simple counting is not the solution because animals often skip a day but do not, so far as we know, double up. Actual counts generally underestimate the number of days (remember Wells's original modern corals with an average of 360, not 365, daily bands—on very cloudy days, daytime growth may not exceed night growth and bands may not form).

And, to pose the most basic question of all, how can we be certain that lines reflect an astronomical periodicity at all? Too often, little beyond the geometric regularity of lines has inspired an assumption that they record days, months, or years. But animals are not passive machines, dutifully recording astronomical cycles in all their regularities of growth. Animals have internal clocks as well, and these are often keyed to metabolic rhythms with no apparent relationship to days, tides, and seasons. For example, most animals slow down their growth rates greatly as they advance in age. But many growth lines continue to increase in size at a constant rate. The distance between septa of *Nautilus* increases constantly and regularly throughout growth. Are septa really deposited once each month, or do later ones measure longer amounts of time? *Nautilus* may live by the rule: grow a septum after reaching a regularly increasing chamber volume, not grow a septum each full moon.

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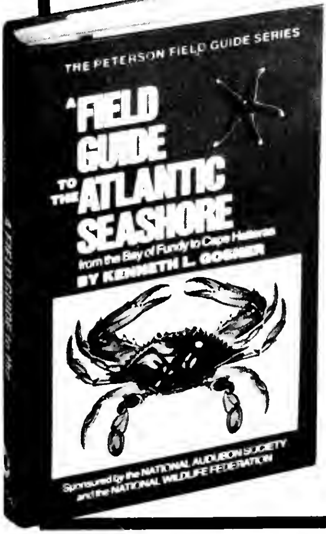

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lems is a body of poorly synchronized data. Uncomfortably large differences exist in the literature. One study of supposedly lunar periodicities in corals suggests that about 350 million years ago the month contained three times the number of days that Kahn and Pompea would allow.

Nonetheless, I remain satisfied and optimistic for two reasons. First, despite all internal asynchrony, every study has revealed the same basic pattern—decrease in the number of days per year. Second, after an initial period of uncritical enthusiasm, paleontologists are now doing the required hard work—experimental studies on modern animals in controlled conditions—to learn just what the lines represent. Criteria for the resolution of discrepancies in fossil data should soon be available.

Scarcely any geologic subject could be more fascinating or more beset with juicy problems. Consider the following: if you extrapolate back through time the current recession of the moon as estimated from eclipse data, the moon enters the Roche limit about one billion years ago. Inside the Roche limit, no major body can form. If a large body enters it from outside, results are uncertain, but certainly impressive. Vast tides would roar across the earth and the lunar surface would melt, which, conclusively from dates on Apollo rocks, it did not. (And the recession rate estimated from modern data—5.8 cm per year—is much less than the average advocated by Kahn and Pompea—94.5 cm per year.) Clearly, the moon was not this close either a billion years ago or ever at all since its surface solidified more than four billion years ago. Either rates of recession have varied drastically, and were very much slower early in the earth's history, or the moon entered an earth orbit a long time after the earth's formation. In any case, the moon was once much closer to us, and this different relationship should have had an important effect on the history of both bodies.

As for the earth, we have some tentative indications in some of our earliest sedimentary rocks of tidal amplitudes that would put the Bay of Fundy to shame. And for the moon, Kahn and Pompea make the interesting suggestion that its closer position and the earth's stronger gravitational pull at that time may explain why the lunar maria are concentrated on the visible, earthward side (the maria represent

vast extrusions of liquid magma), and why the moon's center of mass is displaced in an earthward direction.

Geology has no more important point to teach than the vastness of time. We have no trouble getting our conclusions across intellectually—4.5 billion years rolls easily off the tongue as an age for the earth. But intellectual knowledge and gut appreciation are very different things. The sheer number 4.5 billion is incomprehensible, and we resort to metaphor and image to emphasize just how long the earth has existed and just how insignificant the length of human evolution has been—not to mention the cosmic millimicrosecond of our personal lives.

The standard illustration is earth history as a 24-hour clock with human civilization occupying the last few seconds. I prefer to emphasize the accumulated oomph of effects utterly insignificant on the scale of our lives. We have just completed another year and the earth has slowed down by another 1/200,000 second. So blinking what? What you have just read is what.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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Embattled Preserve

THE ADIRONDACK PARK, by Frank Graham, Jr. *Alfred A. Knopf, Inc., $15.00; 314 pp., illus.*

A Political history, the subtitle of Frank Graham's new book, is commendably correct, but modest. The vast park preserve and mountain wilderness, more than six million acres carved from the watershed between the Saint Lawrence and Hudson rivers, is unique. More than 69 percent of the land, a tract that in its entirety is larger than Massachusetts or New Hampshire, is privately owned but legally held "forever wild." The story of the park is thus inherently interesting and Frank Graham tells it well.

If you are neither a New Yorker nor an active conservationist you might know only vaguely that the rich built fabulous resorts in the Adirondacks in the nineteenth century; that there were sanitariums for tuberculosis patients there; that it was a fashionable place for intellectuals to vacation. Ralph Waldo Emerson was a dreadful camper and a worse shot; William James loved it; Sigmund Freud wrote, "Of all . . . I have experienced in America, this is by far the most amazing."

The history of the park combines the twisting threads of conservation/preservation and its adversary companion, urbanization / industrialization. Perhaps the most crucial industrial landmark was the Erie Canal because it opened the way west so "the tide of settlement passed the mountains by, as immigrants and New Englanders alike took the new route toward fertile lands in the west."

State legislation in 1885 established Adirondack Park as a forest preserve loosely encompassing fourteen counties. The new state constitution that took effect in 1895 confirmed the legislation and the fateful clause, "The lands . . . constituting the Forest Preserve as now fixed by law, shall be forever kept as wild forest lands. They shall not be leased, sold or exchanged, or be taken by any corporation, public or private, nor shall the timber thereon be sold, removed or destroyed." The language turned out to be almost as provocative as that of the first and fifth amendments to the United States Constitution. Not the least of the problems was that by the middle of the twentieth century "the Blue Line [the park's area] was really an ecological rather than a political boundary, encircling the forests of a . . . mountainous region at the point where they gradually faded into the neighboring flatlands."

Graham's political history not only gives details of more than a century of legislative and court battles but also places them in the broad social context of a modernizing America. Thus, Graham understands the importance of the railroads, for example, which made the mountains accessible to the wealthy, made it possible for hardwood to be shipped out, but also brought the constant danger of fire. He connects the rise of the big cities to the awareness of distant urban watersheds during periods of drought and puts the creation of the forest preserve in the context of the three great parks established in the preceding fifteen years: Central Park, Yosemite, and Yellowstone. Graham is careful and precise in unraveling the modern dilemmas for the spectrum of

by Eden Ross Lipson

conservationists. He explains the philosophical contradictions inherent in roadways through the wilderness, reminding us that "Mozart is said to have crossed the Alps in a carriage without looking up from his musical score." He reports "there is no true 'rural' buffer zone between wilderness and the more blatant and dreariest aspects of civilization . . . the physical choices often seem to be between the pristine and the mucked up." Graham quotes the "theme park" proprietor saying, "Just what is there for the average tourist to *do* in an area which has only scenery?"

The Adirondack Park is also an unintentional but endearing salute to the WASP eccentric—a vanishing breed in our era of ripe, strongly seasoned, and proud ethnicity. The book is full of fine sketches of some woodsmen (no women) and self-chosen leaders, including Verplanck Colvin, the man who "measured the mountains"; Harry "Adirondack" Radford, who formed the Association for Restoring the Moose to the Adirondacks, Dr. Edward Livingston Trudeau, who developed the Adirondack Cottage Sanitorium, Rev. William H. H. Murray, who lured tourists with his book *Adventures in the Wilderness*, Gifford Pinchot, the father of modern forestry, and Melvil Dewey of decimal fame, who managed the exclusive Lake Placid Club according to his own racist and anti-Semitic standards. Many others were just three named rich men who lived in and loved the mountains.

Eden Ross Lipson is an editor of the New York Times Book Review

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Big Bullfrogs in a Little Pond

by Richard D. Howard

Females prefer large males, and large males will mate with any interested female. So the larger the male, the more offspring he will sire

With the passing of dusk, the lush vegetation of midsummer gradually fades from view and nocturnal creatures begin to stir. Crickets chirp softly from clumps of grass; in the trees, whippoorwills broadcast their seemingly incessant demands, and the eerie sound of screech owls can be heard in the distance. For people living near ponds and marshes, however, these soft nocturnal noises go unnoticed, for here, the deep bellowing of chorusing bullfrogs dominates. Such is definitely the case in the E.S. George Reserve in southeastern Michigan, where for the past four years I have followed the mating behavior of bullfrogs in five-acre Crane Pond.

Bullfrogs are common in this area, as they are throughout most of the eastern United States and southern Canada. In Crane Pond the mating season begins in June and lasts through July. Each day, males start sporadic calling soon after dusk. Gradually, they call more regularly until, about midnight, a full chorus develops. Calling continues unabated until dawn. The call of a single male is often described as "jug-o'rum"; the sound of thirty or more males calling can only be described as a roar.

This chorusing signals the beginning of a new life cycle of the largest North American frog. During mating, each female deposits thousands of fertilized eggs, which hatch into young tadpoles in two to five days. Soon after hatching, tadpoles begin a herbivorous diet and do not metamorphose into young frogs until one or two years later. These young frogs will become sexually mature in one year (most males) or two years (many females). After maturation, they continue to grow throughout their adult lives; in Michigan, the largest may exceed seven inches in length and weigh nearly one pound. Owing to predation and overwintering mortality, adults rarely live longer than five years; in captivity, however, they have been known to live fifteen years or more.

Unlike tadpoles, adult bullfrogs are voracious predators, readily consuming insects, crayfish, other frogs, and even small birds and mammals. As a result, when they were introduced into several western states, their predacious habits often had a serious effect on local faunas. Bullfrogs are, in turn, hunted by several predators, including humans.

Although bullfrogs provide familiar sights and sounds along many shorelines, their mating behavior was generally unknown until recently. The reason is simple: most matings occur in the early morning hours, usually after 3:00 A.M., and few naturalists are willing to endure the ceaseless onslaughts of mosquitoes for that long.

About thirteen years ago, Stephen T. Emlen, now at Cornell University, observed the same population of bullfrogs that I now study. His work was among the first to describe the aggressive and territorial nature of males and the tendency of females to actively select certain males as mates. His findings surprised many biologists because complex mating behavior was unexpected in frogs. Since then, intensive studies on other species of frogs and toads have revealed a great diversity of mating systems.

I began to study bullfrogs to test the concepts of sexual selection that Darwin had developed in 1871. This form of natural selection really asks two questions: Why do males of most species compete more vigorously for mates than females, and why are females of most species more discriminating than males in terms of mate suitability? Bullfrogs are well suited for such a study. They are highly visible, occur in large numbers, individuals can be readily marked for field identification, and their external method of fertilization leaves no doubt as to the true male parentage of offspring. I wanted to discover, in particular, why males are territorial, why females are so selective in their choice of mates, and whether some males reproduce more successfully than others.

Efforts to answer these questions provide many memorable experiences. Upon entering a small boat in Crane Pond near midnight, one is greeted enthusiastically by mosquitoes that will remain faithful companions all night. As the cooling air settles on warm pond water, the rising mist brings a damp chill to the air and can severely restrict vision. Sometimes, bright moonlight gives the entire area a soft beauty that never exists in the daytime. The pungent aroma of algae and decaying plants often pervades the air.

Approaching the chorusing bullfrogs, one is initially impressed by the activities of large territorial males. Their loud calls and explosive charges enable each male to defend an area, six to twenty feet in diameter, that he deems his own. When a male enters the territory of another and calls, the resident male slowly approaches, giving threatening vocalizations. If the intruder persists, he is attacked. A wrestling match soon follows, a contest of brute strength. Fighting males emit deep growls and muffled calls.

Degginger

George Herben/Photo Researchers

Bullfrogs breed in marshes and ponds, habitats that provide water year-round for the largely aquatic adults. The frogs seldom live more than five years because of predation and overwintering mortality.

While wrestling, they gouge each other's sides with their thumbs, producing small bruises but little other evidence of physical injury. Eventually one male overpowers the other, sometimes holding the losing male underwater for as long as ten minutes. During this time, the loser hangs limp in the grasp of the victor until released, then darts quickly away. Disputes between males are not always settled in one wrestling match; repeated challenges occur, especially if the contesting males are similar in size. The winner is almost always the larger male. Thus, larger males have the potential of controlling any area that might increase their attractiveness to females.

In contrast to the conspicuous activities of territorial males, females are highly secretive. They remain well away from chorusing males until they are ready to mate. When a receptive female enters a chorus, she moves silently from male to male, often approaching to within a yard of a male only to leave and visit another. During her search, the female is presumably evaluating the suitability of the males as mates or the quality of male territories, or both. After observing several, sometimes all, of the males in a chorus, the female swims up to a male and touches him. As the female approaches, the territorial male remains motionless and gives several prolonged low-volume calls that are quite distinct from his normal territorial call. Only after the female touches him does the male move to clasp the female.

Males remain clasped to females, a

behavior known as amplexus, until all the eggs are fertilized. But a female may not begin depositing eggs right away; the interval between clasping and egg deposition varies widely among different frog species. The record perhaps belongs to a Central American frog in the genus *Atelopus*; in this species, males remain amplexed to females for more than 120 days. More typical durations of amplexus for North American frogs and toads range from five to twenty-four hours. Much of the delay appears to result from the time it takes to find a suitable place for egg deposition. Since among bullfrogs territorial males control deposition sites, such search time is not necessary and durations of amplexus are much shorter, pairs usually [illegible]

[illegible]

Bullfrogs are voracious predators. The female, top, is consuming a juvenile frog. Insects, crayfish, and even small birds and mammals make up part of their catholic diet. Above, two smaller, parasitic males maintain a low profile near a larger territorial male. The intruders do not call, but will attempt to intercept and mate with any female that the larger male attracts. The latter spends much time trying to drive such parasitic males away, but his efforts provide only temporary relief. The female remains completely underwater during amplexus, right. The male, on top, keeps a loose hold on her, and within ten minutes she will release from 6,000 to more than 20,000 eggs.

chorusing site entirely. Males immediately resume calling and fighting, their eagerness for another mating seemingly undiminished.

Larger males have a considerable reproductive advantage. At Crane Pond, a larger male may mate as many as six times in one year. Since the total number of matings per year is usually less than forty, such a male obtains 15 percent or more of all possible matings. In contrast, during the past four years, about 50 percent of the males in Crane Pond were unsuccessful in mating. Comparable mating differentials do not occur in females: all females mate at least once and many mate two times each year. The second clutch of eggs, deposited twenty to forty days after the initial one, frequently contains considerably fewer eggs.

Large size confers an additional advantage on males. Larger females selectively mate with the largest males. Since these females may produce more than three times as many eggs as smaller females, the reproductive success of large males is greatly enhanced. Smaller females appear to mate with males of all sizes. Such differences between larger, older females and smaller, younger females could be the result of past mate selection.

Nevertheless, all is not glory for larger males. Activities that increase chances of obtaining mates also increase chances of being eaten. The major predators of adult bullfrogs during the breeding season at Crane Pond are snapping turtles, *Chelydra serpentina*. Snappers appear to be attracted by the commotion the larger bullfrog

males make when calling, fighting, and mating. As a result of such predation, older, larger males are selectively removed from the population. I have never observed young males attacked by snapping turtles, and the only female killed was attacked while mating. In one year alone, I saw seven of the largest males killed by snappers. Since the entire population only contained thirty nine males that year, the effect of snapper predation was dramatic.

Males in breeding condition vary considerably in size and age. One year old males only four inches long are no match, physically, for five year olds that may exceed six inches in length and be nearly three times heavier. As a result of such physical inequalities, males of different sizes often use different behaviors to obtain mates. Unlike larger territorial males, smaller males rarely call or fight. Instead, they maintain a low profile in the water with only their heads above the surface. They swim to within feet of large territorial males and wait, motionless. When a female approaches the calling territorial male, the smaller male quickly attempts to intercept and clasp her. I have termed the behavior pattern of smaller males "parasitism." If a parasitic male successfully amplexes a female, the mated pair is usually driven from the larger male's territory and may spend a few hours searching for another place to deposit eggs. During this time, the female may attempt to dislodge the parasitic male by kicking about violently. Although I have now witnessed nine amplexes by parasitic males, I have never seen females successfully dislodge any males. Females eventually acquiesce to their persistent suitors and deposit their eggs within fifty to one hundred feet of the original territory, provided no other contesting males are nearby. Unfortunately, such areas are usually of lower quality and relatively few offspring survive.

Parasitic males are selective about which male they frequent [illegible] the largest territorial male [illegible]. Some territorial males may have up to five parasitic [illegible] and spend many hours driving the [illegible] away. The slow, threatening approach of territorial males provides the [illegible] ample opportunity for a quick [illegible] treat, but [illegible]

Ma[illegible]

ferent behaviors to obtain mates. These males actively call and appear territorial, but if challenged by a nearby male, they dart away to find a new site and resume calling. These males often occupy territories created when territorial males leave or fall prey to snapping turtles. However, the tenure of such opportunistic males in any one location is brief. Encounters between neighboring males are frequent during the night and it is only a matter of time before a larger male threatens. Opportunistic males seldom stay to fight and can often be seen calling from numerous locations on the same night.

The particular behavior pattern used by a male appears to depend on his size relative to other males. Every male is completely capable of performing each behavior. For example, if a male is very small relative to other males, he will probably become parasitic. If the other males are also small, then the male may defend his own territory. By varying the behavior pattern to meet existing conditions, males may not only minimize energy loss and the risk of being eaten but also maximally exploit any differential ability of other males to attract females.

Why do female bullfrogs prefer larger males as mates? What do they get out of being selective? My attempts to answer this question have centered on how well the eggs fertilized by various-sized males survive to hatching. I took samples of about one hundred embryos from each egg mass every ten to twelve hours until the embryos hatched, then estimated the percentage of offspring living at various stages of development. Since many of the egg masses were sired by males of different sizes, I could relate male size to embryo survival. The results were startling. After analyzing more than 30,000 embryos from sixty-two egg masses, I found that larger males definitely controlled egg deposition sites that increased offspring survival. This results in an obvious advantage for discriminating females.

Embryo mortality generally results from developmental abnormalities and from predation by the leech *Macrobdella decora*. High water temperature (above 90° F) is the chief cause of developmental abnormalities. Such losses are relatively minor, however, because bullfrogs usually avoid mating in extremely hot areas of the pond. In contrast, leeches pose a more serious threat. They often begin infesting egg masses while eggs are still being deposited. Sometimes, more than twenty leeches writhe through a mass of embryos and consume nearly 50 percent of them on average before they hatch.

A leech forages by probing through the egg mass, enveloping an embryo with the anterior third of its body, and sucking out the contents. The foraging efficiency of leeches is reduced by the gelatinous material surrounding the embryos. A seemingly helpless embryo can be a rather elusive prey when embedded in a thick jelly matrix. The vegetation of the egg deposition site further affects the success of leeches. Egg masses deposited initially as a surface film soon sink and settle upon submerged vegetation. If the underlying vegetation is dense, the resultant egg mass is essentially a monolayer; the firm base of vegetation is like a table on which the leeches can take their meal rapidly. If the underlying vegetation is sparse, different parts of the settling mass of eggs come to rest on branches at various depths, and the egg mass is more three dimensional in shape. Most embryos are well protected by jelly on all sides, making their capture by leeches more difficult.

Water temperatures in egg deposition sites can also affect predation losses. Eggs deposited in cooler sites develop slowly, providing leeches more time to forage. As a result, many more embryos are eaten. More rapidly developing embryos in warmer areas literally outrace the leeches, and far fewer of them are consumed. Thus, territorial males and discriminating females may obtain a reproductive advantage from the ability to select just the right temperature for their eggs: not so hot as to cause developmental abnormalities that kill offspring and not so cold as to provide leeches more opportunity to eat developing embryos.

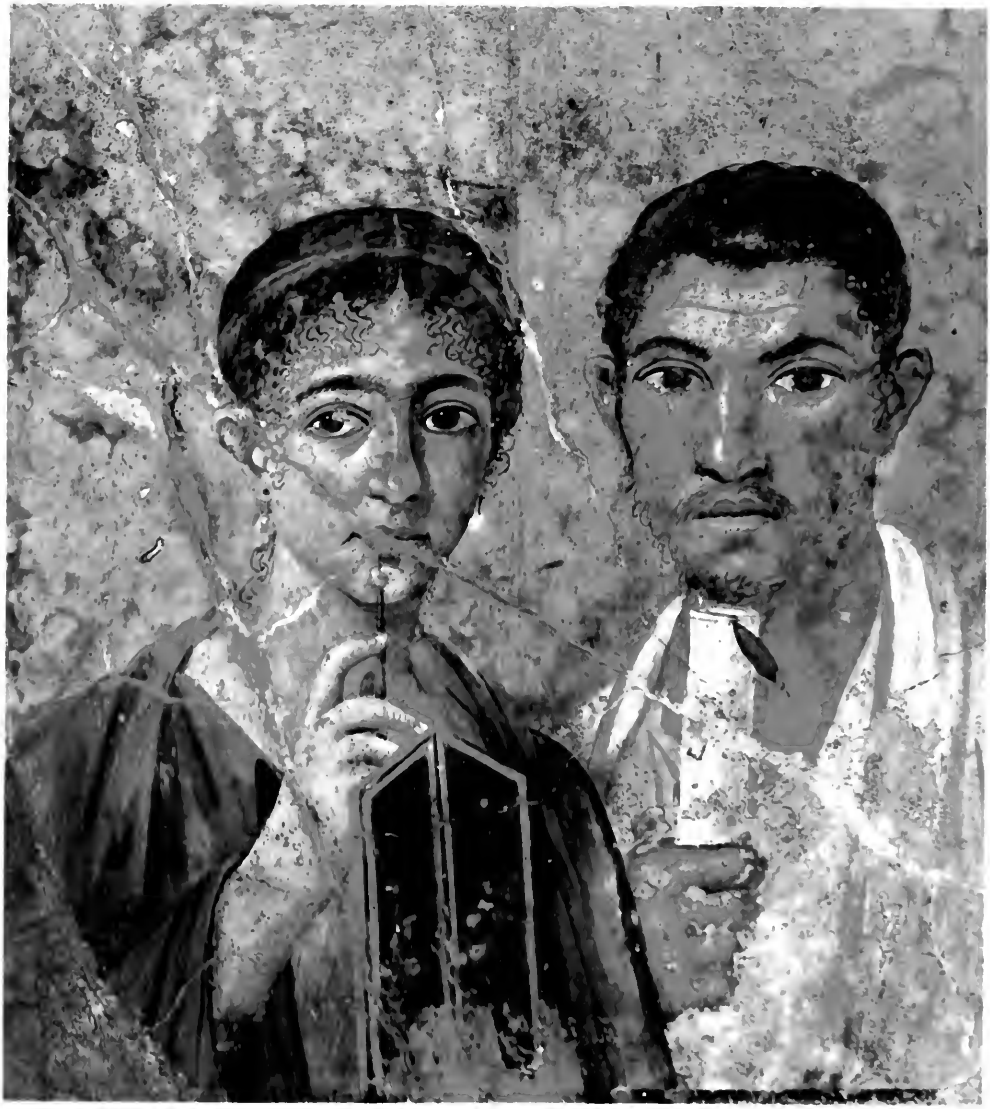
Embryos that hatch face new hazards. Within a day the young tadpoles disperse from their egg deposition sites. Many of the benefits their male parents took such risks for, and their female parents sought so hard to gain by being selective, no longer exist.

The tadpoles are now on their own and soon encounter a different type of threat to their survival: the thousands of other tadpoles in the pond that also seek the best food, places to sun, or some other requisite. In some years, such resources may be in short supply and the resultant intraspecific competition could mean decreased growth rates or even death. Tadpoles also suffer predation by various vertebrates. Fortunately for those in Crane Pond, no fish predators live there; tadpoles in other ponds are not as lucky. The tadpoles then experience their first winter. For many it is also their last. After the spring thaw, thousands of dead tadpoles can be seen floating in the water; presumably they died as a result of oxygen depletion in the ice-covered pond during the long winter.

By early summer, several thousand tadpoles still remain. They continue to grow and, if they are large enough, begin the fascinating process of metamorphosis. In the later stages of development, the half frogs-half tadpoles are relatively clumsy, making them easier prey. After completing metamorphosis, juvenile frogs still face unrelenting predation from snakes, birds, and mammals. Another predator also lurks for them: adult bullfrogs.

Juvenile frogs that survive such onslaughts face still another winter before they can breed. To get some idea of the amount of mortality suffered by juvenile frogs, I marked nearly one thousand of an estimated three thousand juveniles late one fall. Not one marked individual was observed the following spring and fewer than twenty of the original three thousand survived to sexual maturity. The total mortality from egg to breeding adult is astronomical. In 1976, for example, at least 400,000 eggs were deposited in Crane Pond; a little more than 200,000 survived to hatching. Of those that hatched, probably less than forty became sexually mature. Thus the chances that an egg will produce a sexually mature frog must be about 1 in 10,000.

Sexual maturation does not bring any relief from the rigors of nature. Now the young females must take on additional risks to produce their first small clutch of eggs. Young males must compete with older males, often three times their size, for females; as a result, they usually utilize parasitic behaviors and have little chance of fertilizing a female. Thus, the mating system of their species, which evolved countless generations ago, greatly reduces the prospect of successful reproduction for these young adults. Their best chance to produce offspring of their own is to grow large enough to hold more eggs (females) or to dominate their rivals (males), before a snapping turtle attacks or some other disaster befalls them. Fortunately, for those of us who find beauty in their hoarse calls, some will succeed. □



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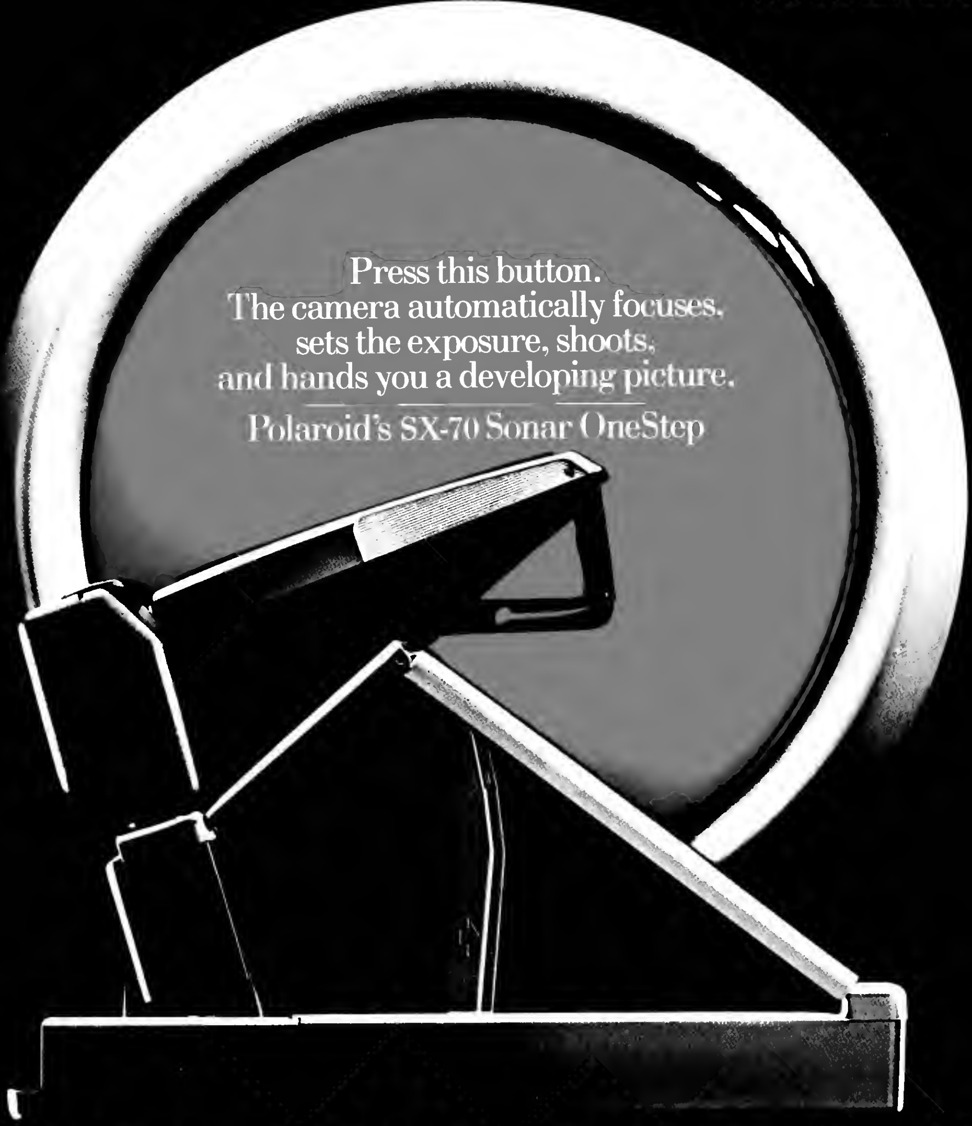

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POMPEII A·D 79

On April 22, "Pompeii AD 79," an exhibition of more than three hundred objects from the buried Roman city, opens at the American Museum of Natural History. Looking at ancient Pompeians' gold jewelry and silverware, sculpture, mosaics, wall paintings, tools, and cooking pots, we feel that the city is very near and have difficulty believing that life in its streets stopped so long ago. Actually, Vesuvius's eruption in A.D. 79 came only just in time to preserve Pompeii as a frozen exemplar of Roman life. Already seriously damaged by an earlier earthquake and affected by economic reversals throughout the surrounding region of Campania, Pompeii might not have long remained a gracious retreat for wealthy Romans—and a rowdy holiday town of gladiatorial spectacles and gambling for less well-to-do citizens. But when disaster struck, the House of the Faun, a noble dwelling that occupies an entire city block, was still standing, affording a glimpse into the workings of patronage, a Roman institution that governed public and private obligations in Pompeii. Pompeii's inns, which provided the more accessible worldly pastimes of open-air dining, drinking, and gambling, resemble modern trattorias. The inns, the public baths, and the spectator sports at the Forum attracted tourists from nearby towns and more distant parts in search of pleasures of the flesh that seem completely contemporary.

Ann Marie Cunningham

In 1813, French neoclassic painter Pierre-Henri de Valenciennes, following Pliny the Younger's account of his uncle's death, painted The Eruption of Vesuvius and the Death of Pliny, *now in the Musée des Augustins, Toulouse.*

FIERY VESUVIUS

by Martin Prinz

"I cannot describe its appearance and shape better than as resembling an umbrella pine tree, with a very tall trunk rising high into the sky and then spreading out into branches. . . . At one moment it was white, at another dark and dirty, as if it carried up a load of earth and cinders."
Pliny the Younger, Letters

In A.D. 79, an inundation of volcanic debris erupting from Mount Vesuvius simultaneously assured Pompeii's past and future. But even if it had not destroyed this bustling town on the shores of the Bay of Naples, the volcano would have been one of the most famous in the world. Vesuvius, which is by no means extinct, has had a long, spectacular history. It stands in a densely populated area of southern Italy, first settled by Greek colonists before 700 B.C. Its records are the most complete of any currently active volcano; many scientific theories about volcanoes, especially earlier ideas, were inspired by Vesuvius. On its slopes is the oldest of the few existing volcano observatories; this center began keeping records in 1845, monitoring all phases of the volcano's activity, not just major eruptions. Every volcano has unique patterns, so that although Vesuvius's history is well known, it is not easily applicable to another site.

The city of Naples and its suburbs along the Bay of Naples, including the site of Pompeii, are built on older volcanic rocks and craters. On the northern side of the Bay are the Phlegraean Fields, a relatively quiet volcanic field of about nineteen craters. Some of the active craters contain lakes or once did. The Fields' dark volcanic rocks and depressions, and the gases and steam rising periodically out of the lakes, inspired at least two poets. In the *Aeneid*, Virgil wrote that one crater, Lake Avernus, was the entrance to the depths of hell. The area similarly inspired Dante's vision of hell as described in his *Inferno*.

Vesuvius itself is part of a chain of currently or recently active volcanoes that extends along the west coast of Italy, to the Lipari Islands near the toe of the boot, and on into Sicily. The northern part of the chain starts at Larderello, southwest of Siena, known for its development of geothermal power. Near Rome, the Alban Hills (site of Castel Gandolfo, the pope's summer home) belong to this same volcanic chain. Its most active parts are near its southern end, and include Stromboli and Vulcano in the Lipari Islands, and Mount Etna in eastern Sicily. The word *volcano* derives from Vulcano; both the island and the volcano were probably named in honor of Vulcan, Roman god of fire and metalworking.

The Italian volcanoes are part of a longer chain, the Alpine-Himalayan belt, which extends from the western Mediterranean up Italy, swings around the Alps and down western Yugoslavia into Greece, then continues eastward into Turkey, Iran, and Afghanistan. This chain developed for the same reasons as volcanic and active earthquake belts in Japan, the Aleutians, Indonesia, the Andes, and many other areas, including the very clear island arcs, known as the Ring of Fire, along the margins of the Pacific Ocean. These belts exist because of the continuous drift of continents across the earth.

According to the concept of plate tectonics, the earth is made up of six major plates and a number of minor ones, each moving slowly but relentlessly at the rate of a few centimeters a year in a specific direction determined by convective flow deeper in the earth. When a major plate collides with another, one of them may slide downward underneath the other, where it forms what is called a subduction zone.

As it is forced downward, the leading edge of a plate becomes subject to ever increasing pressure and heat. The plate becomes unstable and begins to melt in some areas. As melting continues, the resultant lightweight molten rock, called magma, works its way upward and collects

Left: This wall painting of an ibis, a bird sacred to the Egyptian goddess Isis, is now in the National Archaeological Museum in Naples. It came from the goddess's temple in Pompeii, the only public building fully repaired after the A.D. 62 earthquake, which presaged Vesuvius's eruption in 79. Below: In 1754, Carl Weber, who excavated at Herculaneum, drew this map of Vesuvius and the Bay of Naples.

nal Photocolor Archives

in pools, which are eventually driven to the earth's surface by gaseous pressure that has built up, mainly in the form of steam. Magma arrives at the earth's surface as ash or, in a molten state, as lava.

The Italian volcanic chain, of which Vesuvius is a part, is the result of Africa's movement in a generally northwesterly direction. As it does so, it collides with Europe in a group of complex minor plates. The resultant subduction zones produced the curved patterns of this part of the Alpine-Himalayan belt.

In this view from Pompeii's Forum, the Temple of Jupiter dominates the north end and Vesuvius rises to the northwest. At left is the volcano's present cone, which appeared after the eruption in A.D. 79; at right, part of the old cone, now called Mount Somma, is visible.

Vesuvius probably started erupting about 10,000 years ago, very recently indeed in its chain's history. In Europe, the last glaciation began retreating about 11,000 years ago, and Vesuvius's eruptive material is believed to be younger than the glacial deposits. The first eruptions of the Phlegraean Fields were buried by Vesuvian materials; therefore, these craters must have been active before Vesuvius.

The ancients did not describe Vesuvius as a volcano, so there may have been a long period of quiescence between its early activity and the arrival of Greek colonists who settled on its slopes. The Greeks were familiar with volcanoes, having been forced to flee other settlements on their account. They may not have recognized Vesuvius as a volcano, or they may have decided that it was extinct. Perhaps, like modern inhabitants of Vesuvius and Californians who live on or near the San Andreas fault, the Greek arrivals guessed that the region's fertile soil was worth what they considered the small risk of volcanic activity.

During the century prior to A.D. 79, some Romans may have been aware that Vesuvius was a volcano; one observer noted that its slopes were cindery, as though they had been

"eaten by fires." About 72 B.C., some of the Roman gladiators who rebelled under the leadership of Spartacus sought refuge on the summit and later described the crater in detail. According to these sources, Vesuvius had a broad, flat summit with a deep crater and a narrow opening on one side. Because the crater was not visible from below, many early inhabitants probably thought of Vesuvius as just another large mountain. Today this cone, now known as Mount Somma, remains as a sharp crater wall partly encircling Vesuvius. From the name of this cone comes *somma*, the geologic term for a remnant of an older volcanic cone.

The first sign of renewed activity at Vesuvius came on February 5, A.D. 62, when a severe earthquake wreaked considerable damage on Pompeii, Herculaneum, and other small communities that are now part of Naples. Apparently not overly alarmed, Pompeians set to work rebuilding their city.

That Pompeians did not associate the A.D. 62 earthquake with Vesuvius is not surprising. Minor earthquakes continued to shake the area for the next sixteen years, and had the inhabitants been aware, as we are now, of the patterns of seismic activity that precede volcanic eruptions, they might have foreseen the impending disaster.

On August 24, A.D. 79, there was a series of extremely violent shocks, followed shortly by the classic eruption, which lasted two infamous days. Immediately afterward, survivors saw that about half of Vesuvius's old cone had disappeared, and a new cone, the present-day Vesuvius, had risen above it. Not only were Pompeii and Herculaneum completely buried, but ashes and fumes reached Stabiae, more than ten miles south of Vesuvius. Here the Roman natural historian Pliny the Elder, aged 56, was among the casualties. About six years later, his nephew Pliny the Younger wrote the only eyewitness account of the great eruption in two letters to the historian Tacitus, who was trying to record the circumstances under which Pliny the Elder died. These letters give a remarkably clear, albeit occasionally inconsistent, description of the volcanic events, even though the writer was only eighteen when he witnessed the disaster and more interested in literature than in natural history. Pliny the Younger's letters may be considered the beginnings of the science of volcanology.

Pliny the Younger maintains that about noon on August 24, a cloud of very unusual size and shape appeared. At first it did not seem related to Vesuvius. But as it grew rapidly into a vertical plume, which rose for miles into the sky and then spread laterally in the upper atmosphere, it was clear the cloud was emerging from the volcano. Its form resembled the tall local pine tree; consequently, the scientific term for this type of eruption cloud is *pino*, the Italian word for pine tree. Eruptions accompanied by *pinos* and the violence Vesuvius displayed in A.D. 79 are sometimes called Plinian eruptions.

When the *pino* appeared, Pliny the Elder wanted to study it and planned to sail his galley toward Vesuvius from the small town of Misenum, twenty miles to the west, at the mouth of the Bay of Naples. He invited his nephew Pliny the Younger, who declined, saying he had too much work to do. Pliny the Elder sailed instead for a small coastal town near Herculaneum, where he had friends who had requested help.

As he approached the coast, his boat was showered with hot ashes and lumps of pumice from the volcano, so he turned south and landed at Stabiae, which was not being so heavily pelted. Here he found a friend at his coastal villa, frantically packing some of his possessions. Calming his friend, Pliny ordered a bath, and the pair sat down to a hearty meal.

Below: These plaster casts are of bodies found in the ruins of Pompeii. Right: A detail from a wall painting shows two priests and devotees. Now in the National Archaeological Museum in Naples, it once decorated the Temple of Isis at Herculaneum.

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As night fell on Stabiae, Vesuvius remained an awe-inspiring sight: its dark ash cloud was lighted from below by a red glare, partly from burning villages on the slopes. Pliny slept during the early part of the night while ashes piled up around his friend's house, but the owner and his family, concerned by deepening ash and frequent tremors, could not sleep. They decided to wake Pliny, and the party made a dash for the coast and the boat.

To protect themselves en route from hot lumps of ash, the group tied pillows to their heads and wrapped themselves in towels. Even after dawn, the ash cloud completely blocked the sun, and they had to use torches to pick their way through total darkness. They reached the coast, but found the winds unfavorable and the sea too rough. Pliny, who was beginning to feel ill, lay down and asked twice for water. The sulfurous fumes soon became too noxious, and his friends fled. Pliny arose, attempting to follow, but immediately collapsed. Since the escaping party was far from the volcano, he probably was not poisoned by volcanic gases, but died of a heart attack: he was very heavy and had certainly overexerted himself.

Meanwhile, across the bay, volcanic dust and hot ash were raining heavily on Misenum, and tremors were crumbling and shaking houses. Pliny the Younger and his mother took off for open country. Overhead, a fierce lightning storm was breaking, discharging static electricity that had accumulated in the ash cloud. At one point, through the dim light, mother and son saw the sea recede from a beach, stranding sea life. An earthquake had probably shifted a fault block, temporarily removing the water. Pliny and his mother, enveloped most of the time in total darkness and air filled with ash and panicked screams, were also in danger of being trampled by fleeing hordes of terrified people. This scene of terror was taking place across the bay from Pompeii, at a respectable distance of twenty miles from Vesuvius.

The nightmare continued for many hours into August 25. Finally, hazy daylight penetrated the dusty air, and survivors began to collect themselves and seek out family and friends. They could see that Vesuvius had changed shape radically since the previous day and that fields and vineyards were covered by thick gray ash. There was total silence.

The ash blanketing the region was made of pumice, lightweight gray rock that, because it is filled with air pockets, remains buoyant in water until it becomes waterlogged. Pumiceous ash is produced by magma that contains large amounts of water, resulting in great quantities of steam. When this type of magma rises to the surface as lava, it is rich in silica, very thick and pasty in texture, and does not release its gases easily. Because the magma had lain dormant inside Vesuvius for a very long period, its gases had built up tremendous pressure, which was finally released in a fantastic head of steam. During the two days when the volcano finally uncorked, about ten to twelve feet of hot ash buried Pompeii; the bay also must have been covered in varying thicknesses. Traces of this pumiceous ash traveled through the air as far as Agropoli, forty-three miles away. The entire volume of ash that fell during the eruption would fill a cube 1.5 miles wide on each side.

Although Pliny the Younger's account appears to be accurate, recent research indicates that an additional ash

layer, more tightly consolidated, was deposited on or near the top of the loose ash. In this separate layer, excavators found most of the fossil casts of Pompeii's inhabitants, previously believed to have been killed by roofs collapsing under the weight of the ash or to have been suffocated by sulfurous fumes from the ash cloud. Actually, the majority may have been killed toward the end of the eruption by hot ash flow.

This second type of ash deposit is called ignimbrite. The ash flow and its gases move as a unit, rushing down a volcano's slopes at high speeds, destroying everything in its path. When the ash particles come to rest, they result in a layer of tightly consolidated ash. Ignimbrite has been found in older volcano deposits in various places, such as Wyoming's Yellowstone National Park and the Aleutian Islands. In Pompeii, after nearly all the ash had fallen from the ash- and dust-laden cloud enveloping the city, a ground-hugging ash flow apparently devastated the area. The hot ash may have followed immediately after the loose ash deposits, or several days or weeks later, so that its victims may have been looters. Many fell carrying possessions, including bags of gold and jewelry; at least one was returning to town.

Whether residents or looters, the dead were buried in ash—hot or loose—which hardened shortly after the bodies decayed. Loose ash cemented quickly as lightning from the ash cloud caused heavy rains. Both kinds of consolidated ash made perfect molds of the bodies, in some cases preserving even the imprint of clothing and facial expressions. Nineteenth-century excavators learned a great deal from the hundreds of plaster casts made from these molds.

An ash flow might also explain the dramatic change in Vesuvius's appearance. When ash flow deposits develop in a volcano, so much magma is released that the volcano's underpinning is weakened, and its central part may collapse downward, leaving a large depression called a caldera (kettle in Spanish). A small caldera could account for the large missing portion of Mount Somma, which was not thrown out of the volcano. When Krakatoa erupted in the Pacific Ocean west of Java in 1883, a large caldera developed, displacing an enormous volume of water. Gigantic tidal waves called tsunamis, up to 120 feet high, rushed into

Sir William Hamilton, *Campi Phlegraei*, vol. I. AMNH

Above: This hand-colored eighteenth-century plate is based on a witness's drawing of Vesuvius's activity in late 1760 and early 1761. The lava flow that followed blocked the road from Torre del Greco to Torre Annunziata for some months. Right: From the air, Pompeii's amphitheater is visible at the far lower right. Behind the city, Vesuvius's active cone is on the left, while Mount Somma is on the right.

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coastal areas, killing about 36,000 people. Vesuvius, being inland, caused no tidal waves, but even larger tsunamis must have accompanied the circa 1450 B.C. eruption and development of a caldera on the Aegean island of Santorini. This flood may have been largely responsible for the destruction of the Minoan civilization in Crete.

Herculaneum was another coastal town completely inundated by volcanic debris at the same time as Pompeii, but it is much more difficult to excavate: it was buried under tightly consolidated material that must be drilled or chiseled away, while the ash over Pompeii can be removed with pick and shovel. Unlike Pompeii, Herculaneum was not downwind from Vesuvius; therefore it did not receive heavy ash falls and was presumably buried by the mudflows that resulted when lightning accompanying the ash cloud caused heavy rainfall on the ash-laden slopes.

Although the memory of Vesuvius's eruption remained, the buried towns were forgotten until the first half of the eighteenth century, when well diggers accidentally discovered their sites. For hundreds of years after A.D. 79, Vesuvius's activity merited only passing mention. One description of an eruption in A.D. 203 echoes Aristotle's view of volcanoes as the result of pent-up winds. Another eruption in A.D. 472 spread ash all over Europe and caused distress as far away as Constantinople. During the next six hundred years only four eruptions were recorded, in 512, 685, 993, and 1036.

The eruption of 1036 is particularly important because the lavas of Vesuvius's current period appeared for the first time. A fundamental change in the composition of the magma must have taken place, resulting in more quiescent eruptions of lava rather than explosive eruptions of ash. Until about 1000 B.C., Vesuvius mainly gave rise to lava flows, but from 1000 B.C. until A.D. 1036, it produced only ash deposits. For some volcanoes, the highly explosive ash-producing phase marks the end of activity. Vesuvius experienced a long series of lava eruptions, followed by an ash-producing phase that culminated in major change in the cone. The great eruption of A.D. 79, followed by lesser ash deposits until 1036, could have marked the end of the volcano. But the rejuvenation of lava production in 1036 appears to have been the beginning of a new cycle.

Eruptions followed in 1049, 1138, and 1139, after which came about five hundred years of repose. But the enormous eruption of 1631, a flood of lava and ash, left no doubt that Vesuvius would continue its new life. Vesuvius has since remained in a fairly constant state of activity.

On December 16, 1631, a great ash-filled *pino*, accompanied by explosions, rose from the crater. The next day lava poured out of two fissures, rushed down the slopes into four communities, and reached the sea in about two hours. On the evening of December 17, mud rained on Naples, while mudflows inundated villages on the volcano's slopes. Another lava flow began, followed by strong explosions and *pinos* that continued into December 18. This catastrophic event killed about 4,000 people and 6,000 domestic animals; it destroyed six towns by lava and nine by mudflows.

Since 1631, Vesuvius has followed a rough pattern of repeated eruptions every thirty-five to forty years. Although its eruptive cycle varies in length, the last two ran 34 and 38 years. For 35 years, since the last cycle ended in 1944, Vesuvius has been quiet. A typical cycle begins with a period of repose that lasts about seven years, during which only gases, mainly steam, emerge from the crater. Then minor volcanic activity begins, and small cinder and ash cones build up on the crater floor. For the next twenty to thirty years, minor lavas fill up the crater until they spill over the top or out of small fissures along the side. When the column of molten lava is standing high in the throat of the volcano, steam builds to high pressures. Finally, a blowoff, an eruption full of steam, gives rise to *pinos*. Accompanied by earthquakes and explosions, major fissures open in the cone. For about two or three weeks, lavas flow heavily down the slopes, and the cycle ends, followed by a new period of repose.

Vesuvius's more modern eruptions have been recorded in detail. Sir William Hamilton, from 1764 to 1800 British ambassador to the Bourbon Court at Naples, has left descriptions of the eruption of October 17, 1767, and of one in 1779. An ardent student of volcanoes, Sir William compiled a list of Vesuvius's eruptions up to 1779. In the latter part of the eighteenth century, Vesuvius's cycles were much shorter than they have been since. After the 1767 eruption, the period of repose lasted only three years, and a paroxysmal eruption ended the cycle only nine years later in 1779, when Sir William noted that great explosions were accompanied by "fire fountaining" of molten lava up to two miles high. Lava flows destroyed the town of Ottaiano, caught unawares because the rim of Mount Somma blocked inhabitants' view of the crater.

The next paroxysmal eruption occurred in 1793, when lava flowed down the main street of Torre del Greco into the sea—the third but not the last time that this town was flooded with lava. More eruptions followed in 1822, 1838, 1850, and 1872, when the north flank of Vesuvius's cone split from top to bottom. Lava poured out into the villages of Massa and San Sebastiano. Explosions and *pinos* spread dust and ash widely.

Since the observatory on Vesuvius began work in 1845, good records exist of the cycle between 1872 and 1906. The period of repose ended in 1877, when cones and small lava flows appeared inside the crater. The first flow emerged from the crater in 1881; over the next few years, thick, sluggish lava issued from a number of sites. From 1895 to 1899 lava moved very close to the observatory, which was not damaged.

Before the eruption at the end of this cycle, in 1906, Vesuvius had reached its greatest height, 4,338 feet; after the final blowoff, the cone was 325 feet lower. By April 5, 1906, three major fissures had opened up at various elevations, exuding lava, ash, and cinder with great force. Dense *pinos* spread ash; lightning flashed overhead. Lava from the lowest vent in the cone covered a portion of Torre Annunziata. Many roofs collapsed when about three feet of cindery ash fell on Ottaiano, which had been so badly damaged in 1779. In San Guiseppe a church roof caved in, killing 105 people who had sought refuge. The great gas blowoff marking the end of the cycle began at 3:30 A.M. on April 8 and lasted about fifteen hours.

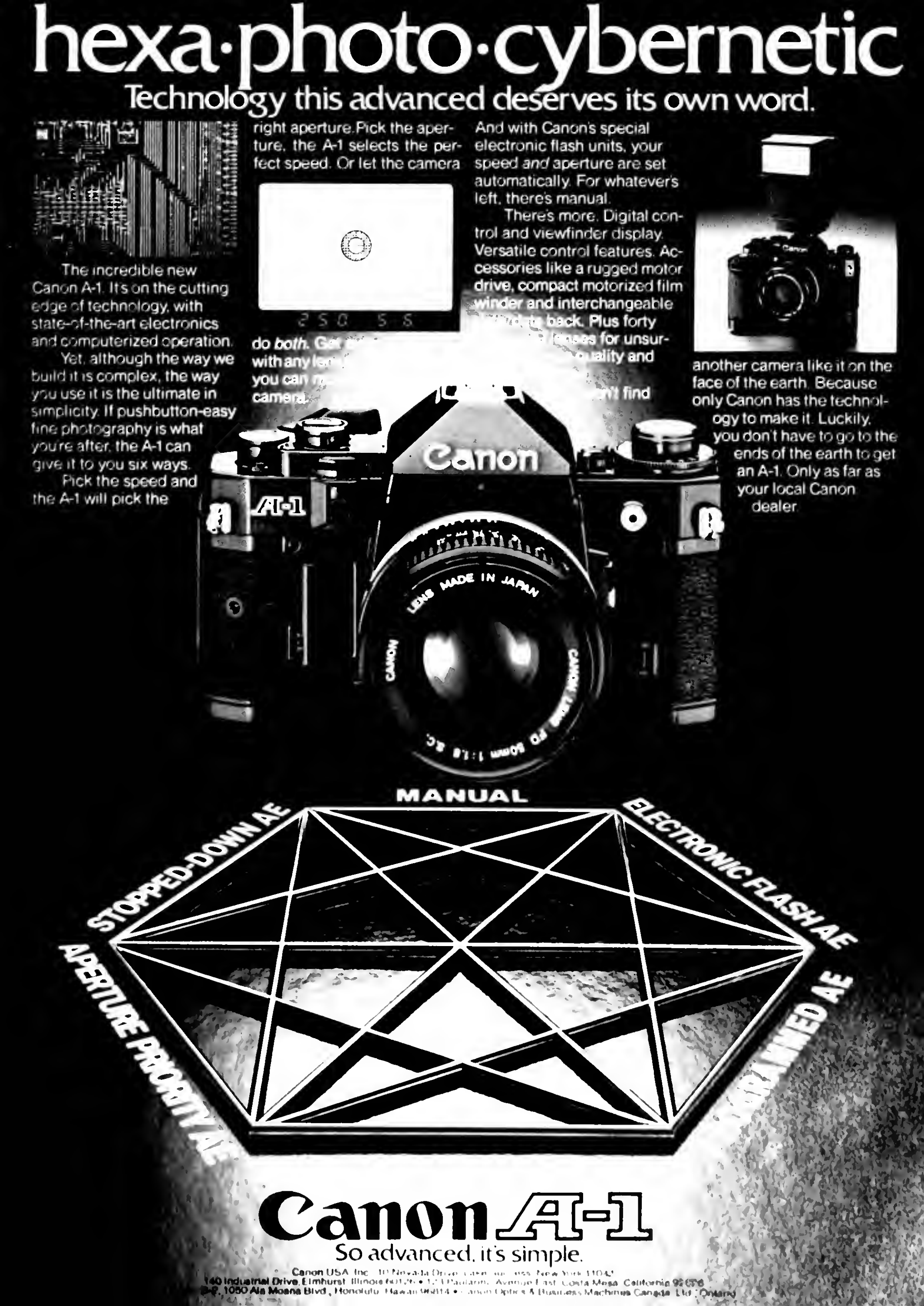
Vesuvius returned to dormancy until 1913; then, for the next thirty-one years, the pattern of cone building and minor lava flows reoccurred. Beginning on March 12, 1944, large sections of the summit cone collapsed, blocking the volcano's throat on successive days. By March 18, explosions had reopened the conduit; lava began to pour over the crater rim and from fissures on the east side. On March 21, it passed through Massa and San Sebastiano, at 165 to 330 feet an hour, leaving only the church and a few taller buildings poking above the lava field. These flows were followed by fire fountains about a half mile high. The final blowoff lasted about ten hours. At the eruption's close, the crater was an elliptical hole about 900 feet deep and about 1,800 feet wide from east to west.

Since 1944, several hundred feet of the crater have been filled in by rocks sliding from the inner walls. Because these slides send great clouds of dust into the air, they have been mistaken for volcanic activity. Since 1944, however, Vesuvius has been resting, much longer than its seven-year average over the last three hundred years. The longer the wait, the more explosive the overdue activity is apt to be.

If there is a reservoir of magma below Vesuvius, its depth could be measured indirectly by earthquake waves from the subterranean chamber. In other volcanoes where magma has been measured by seismic activity, the reservoir is often fifteen to twenty miles down. In Vesuvius's case, the depth of the magma can be measured by studying the local geologic strata. Since limestones dip beneath Vesuvius, upwelling lavas often carry blocks to the surface. When Triassic limestones come in contact with magma, they produce complex metamorphic rocks, some of which carry the mineral vesuvianite. Younger limestones lying on top of the Triassic stratum emerge unchanged. Therefore the depth of the magma chamber under Vesuvius must be the depth of the Triassic limestone, about three miles down.

Some observers theorize that if it reacted thoroughly with magma, the Triassic limestone could have been assimilated into the magma and changed its composition. This hypothesis is controversial but may explain Vesuvius's renewed activity and the change in lava composition that dates from 1036. The volcano has since produced basaltic lava flows, instead of the pumiceous ash of A.D. 79.

The future of Vesuvius and the possibility of another Pompeii are by no means definite. Cycles of basaltic lava flows ending with paroxysmal gas blowoffs probably will continue. Eventually, the lavas will once again become rich in silica and full of water, producing much more violent ash and ash flow deposits during longer cycles. Perhaps a third explosion on the scale of Pompeii will finally close out this vent in the Alpine-Himalayan belt. On the other hand, Vesuvius may renew itself, as it did in 1036, and open a fourth chapter of its long, violent history. □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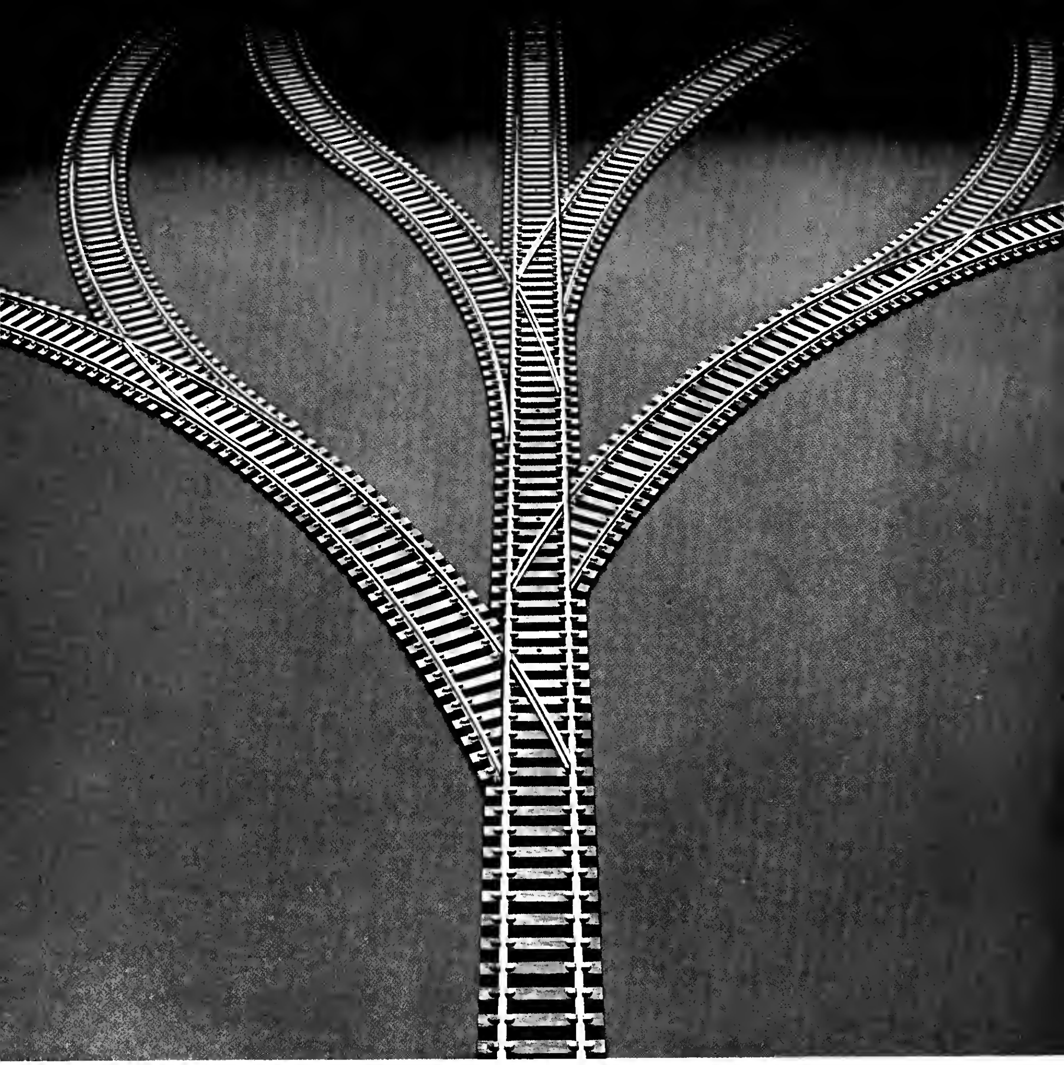

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HOW THE CITY GREW

A modern visitor to Pompeii can walk the same streets and visit the same landmarks that ancient inhabitants knew

by Blanche R. Brown

A marble statuette of Venus, now in the National Archaeological Museum in Naples, was found in southwest Pompeii near the Marine Gate, one of eight gates in the city walls.

Ancient Romans traveling to the Bay of Naples in the mid-first century A.D. would have found that their guidebooks' longest entries dealt with Neapolis, a flourishing city, and Puteoli, a bustling port-emporium. The countryside, the guidebooks would have said, was the Romans' favorite for vacations; here some of the great Roman families, including the imperial family, had sumptuous country homes. Stabiae, called Castellammare di Stabia today, was then, and is again, a bathing resort famous for its mineral waters. About Herculaneum and Pompeii the guidebook would have said less. Herculaneum was a pleasant, largely residential town, with fine houses. Pompeii, with a population of fewer than 20,000, was a minor port, which serviced the inland area from a rise over the sea at the mouth of the Sarno River. Besides trade, Pompeii's citizens lived on the cultivation of vines and olives, supplemented principally by a wool industry based on sheep-raising on inland mountains. With the only amphitheater in the area, the city played host to its neighbors for gladiatorial games.

A modern guidebook to the Bay of Naples would devote more pages to the ancient towns of Pompeii and Herculaneum. In the intervening centuries, Neapolis and Puteoli changed, waned, and grew again, gradually transforming themselves into the modern Italian cities of Naples and Pozzuoli. But the histories of Pompeii, Herculaneum, and Stabiae were rudely interrupted when Vesuvius erupted on August 24, A.D. 79, burying all three under volcanic debris, and bequeathing to archeologists the only complete classical cities caught in the midst of their daily lives.

Herculaneum was rediscovered in 1709, Pompeii in 1748. But for more than a century there was no thought of reconstituting them. Treasure hunters dug or tunneled into the ruins, looking for portable objects or cutting out and carrying away pieces of mural paintings or mosaic floors. The Bourbon kings of Naples and Sicily supervised much of this plunder and received most of the collected objects. In the course of this scavenging, a great deal must have been destroyed, but many pieces that are missing from the sites can be found in the National Archaeological Museum in Naples.

Giuseppe Fiorelli, who was in charge of excavations from 1860 to 1875, conceived the idea of digging systematically, block by block, building by building, leaving as much as possible in place and restoring as he went. At Herculaneum, infinitely more difficult to excavate because it was buried under deeper volcanic material that had solidified, only about six or seven city blocks can be visited today. Fiorelli decided to concentrate on Pompeii, where the debris was loose and only about twelve feet deep. He made plaster casts from the natural molds formed by volcanic ash as it hardened around people, pets, furniture, and wooden moldings, and used casts of the last two to restore buildings. From his time on, the old cities have been reappearing. By 1911, when the so-called new excavations began in the southeast section of Pompeii, techniques had become so refined that buildings could be reconstituted to the second story, including balconies, loggias, and roof tiles. Missing wooden parts could be restored, and surfaces, including exterior walls, could be kept intact with their full complement of shop signs, election declarations, and graffiti. Today more than three fifths of ancient Pompeii has been excavated and more or less preserved or restored.

With a street map and guidebook, modern tourists can move through Pompeii as confidently as any ancient trav-

eler. They can walk paved streets, with stepping stones from sidewalk to sidewalk for pedestrians and ruts left by wagon wheels. Visitors can enter municipal offices, temples, commercial establishments, shops and manufacturies, theaters, an amphitheater, public baths, restaurants and bars, inns, gambling houses, brothels, and many private homes. Several days are needed to find them all, and with more time one begins to feel like a habitué, retracing steps, recognizing streets and sights.

Studying the street map can help; it not only tells where things are but also reflects the history of the city. The section slightly out of kilter in the southeast corner, surrounded by an irregular line of streets, is the site of the original town, which covered only about twenty-four acres and housed about 2,000 people. The irregular periphery follows the line of the old city wall, within which there was a fairly regular grid of streets, with an open space in the middle. The town was founded by either local Italic people or by Greeks, who from the middle of the eighth century B.C. had been establishing colonies in southern Italy and eastern Sicily. The founders' nationality will not be settled until excavations are made under the present surface of the city. The Greeks became the leading power throughout the colonized region, and their influence was strong in Pompeii. The old city walls were built in Greek style, as was the Doric temple, probably dedicated to Hercules, whose foundations are still visible to the southeast, on a spur of land that, in the early days, may have been outside the walls.

In 474 B.C., the Greeks defeated the Etruscans in a decisive naval battle, and the Greek region enjoyed expanding prosperity. During this century Pompeii was enlarged and laid out in its present size and form. It became a city, although a small one, covering 160 acres. The center remained in its old site, although it was off-center now. Some irregularities were built into the city plan, evidently because of familiar routes of travel, such as the streets that replaced the old city wall: the Via Consolare, which followed the line of the old road to Herculaneum, and the oblique Via Stabiana, which seems to follow the line of a country road north to Vesuvius and south to Stabiae. Otherwise the street plan followed a grid, with individual blocks that are long and narrow in the Greek manner. In subsequent centuries Pompeians gradually filled the grid and then overflowed it, so that in the last decades of the city's existence second stories had to be added to most houses, commercial establishments took over many homes, and shops lined the main streets, Via dell' Abbondanza and Via Stabiana.

After Pompeii was enlarged, a number of political upheavals affected the region. Toward the end of the fifth century, Samnites, Italic people from the inland mountains, conquered the coastal area. In the fourth century, Rome began expanding and by 290 B.C. controlled the area completely, although local government remained in local hands. In 80 B.C., Pompeii became a Roman city when the dictator Sulla settled a colony of two or three thousand families of his veterans there. Pompeii's Romanization was completed in 27 B.C. when the first Roman emperor, Augustus, established autocratic rule in Rome. Prosperity continued under all these masters, but leaped forward in the second century B.C., when Rome extended its control to the eastern as well as the western Mediterranean and made Puteoli its major port for trade with the East. Only in the first century A.D. did Italy's and Pompeii's prosperity begin to wane. In A.D. 62 a violent earthquake struck the

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Left: Via Stabiana, one of Pompeii's main streets, has stepping stones in mid-block for pedestrians. Above: In the sanctuary devoted to the Egyptian goddess Isis, the main temple building stands within a peristyle.

Bay of Naples region, causing grave destruction throughout Pompeii. But even by A.D. 79, when the city was buried, not many buildings had been completely renovated and very little new construction had been undertaken.

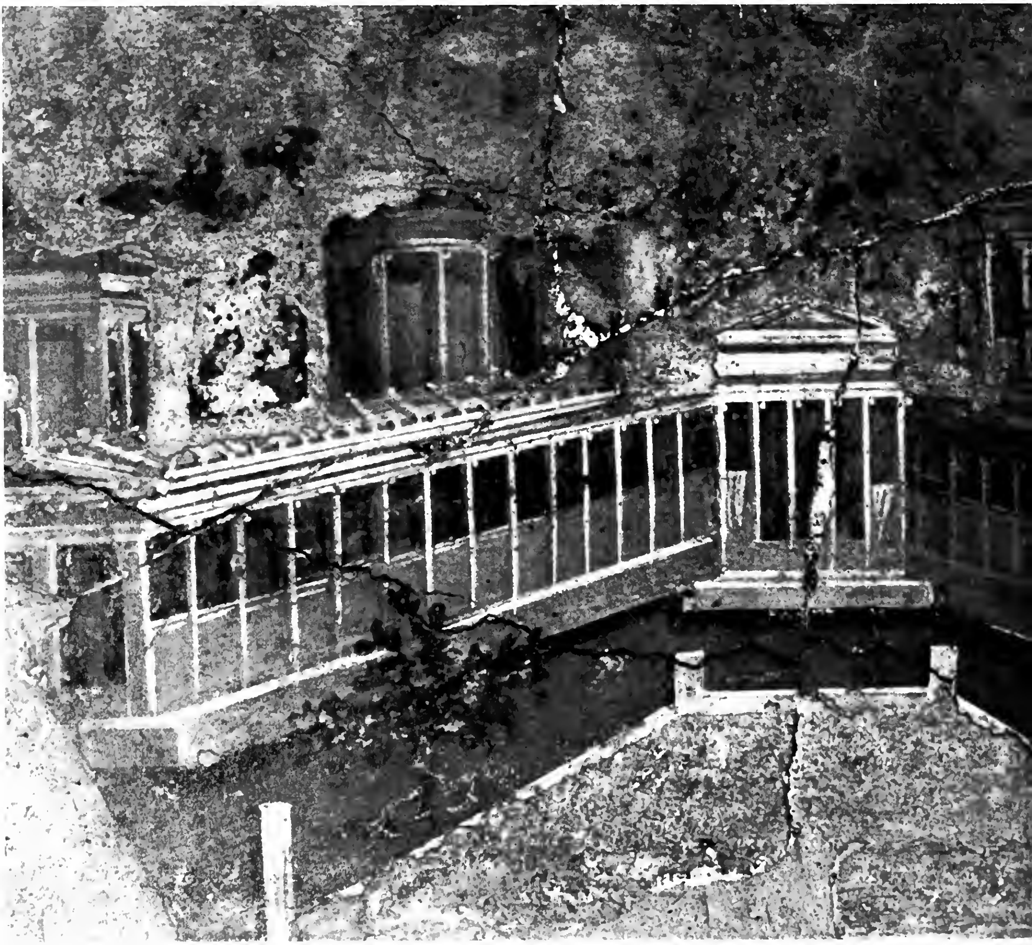
In A.D. 79 Pompeii had few vestiges of the limestone and volcanic-stone buildings of its earliest centuries. The present city consists almost entirely of the brown tufa buildings of the late Samnite period, circa 200–80 B.C., and the stone- and brick-faced concrete buildings of the Roman period that followed. Concrete is the Romans' characteristic building material, developed since the third century B.C. out of a mortar made from volcanic ash first used at Puteoli. Tremendously cohesive and strong, concrete was the vehicle the Romans used to create a new, inventive, versatile architecture, based on arched openings and vaulted interior spaces. In Pompeii, which was conservative regarding structure, the new architectural forms appeared only in the walls of the amphitheater, buttressed with cadenced arcades, and in the rooms of the three public bath buildings, with their stuccoed barrel vaults, spherical domes, and half domes. But Pompeii is a treasure trove of new building types that the Romans introduced. It contains the earliest extant examples of an amphitheater, a basilica, which is a combined market building and law court, and a Roman bathing establishment, many temperatured and many roomed. Theaters, temples, and the meat market have Roman shapes. Homes that line the streets give the fullest picture available of the forms and development of Roman domestic architecture.

One logical way that visitors can explore Pompeii is to start with main streets and public monuments. They can enter Pompeii through the Marine Gate at the city's south

ern corner, which leads to the Forum and the Via dell' Abbondanza. At the gate itself, to the right is the Antiquarium, a small modern museum worth a visit if only for such early fragments as the sixth-century B.C. terra cotta decorations of the Greek temple. A step farther, on the right, is the platform of the Temple of the Pompeian Venus, patron goddess of the city, but there is little to see because the postearthquake rebuilding had not even begun. A little farther along, on the left, is the Temple of Apollo, set in a rectangular precinct with columned portico, partly restored in modern times, with copies of a bronze statue of Apollo and a bust of Artemis placed to right and left, where the originals were found.

Immediately next to the Precinct of Apollo, the Forum opens out, dominated on the north end by the Temple of Jupiter, with stumps of a triumphal arch on each side. Much of the Forum had been surrounded by two-storied tufa porticoes that were being replaced in limestone. But by A.D. 79, the work had not progressed far. Many statues once filled the open space, but only the brick cores of their bases were found. These had been stripped of their marble revetment, as were the surrounding buildings, perhaps by postearthquake reconstruction, perhaps by looters after the eruption. Around the Forum are a number of essential public buildings. Beginning at the northeast side of the Forum are the meat and fish market; a precinct that may be the Sanctuary of the City Lares and a temple to the emperor Vespasian (A.D. 69–79), both built or rebuilt after the earthquake; headquarters of the wool merchants' corporation; and the comitium, where municipal elections were held. On the narrow south end are three public offices: of the *duovirs*, or senior magistrates; of the city council (curia); and of the aediles, or junior magistrates. On the west side stand the basilica, built about 80 B.C.; a grain market; a marble table with hollowed-out receptacles representing standard weights and measures; and a public latrine.

Going north on Via del Foro, to the right is the rather modest Temple of Fortuna Augusta, raised on a high podium, and to the left are the Forum Baths, with beautiful stucco-decorated, concrete-vaulted rooms of various shapes. Across Via di Nola are the remains of a triumphal arch of the emperor Caligula, who reigned from A.D. 37



to 41, which once spanned the street, and held sculpture on top.

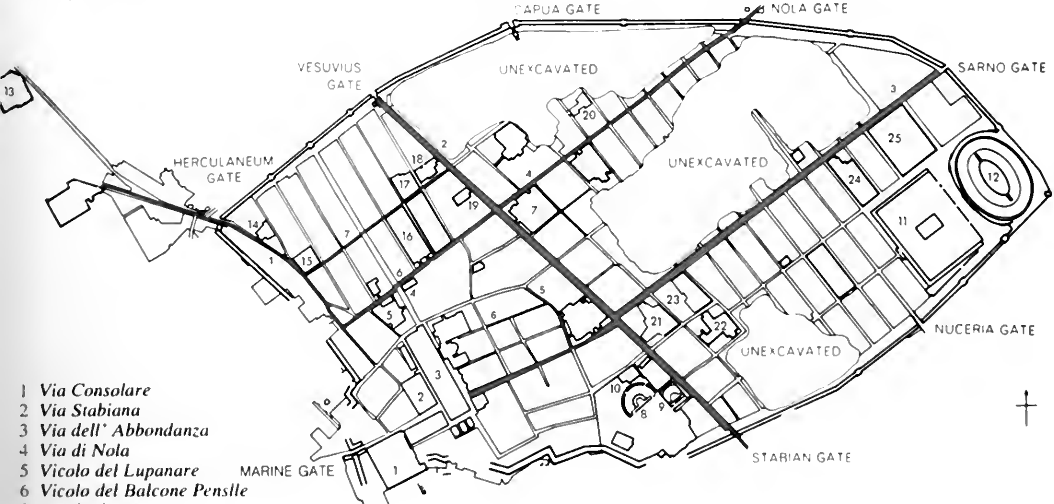
To the right on Via di Nola, about four blocks over, stand the Central Baths, the only new construction begun after the earthquake, but never finished. Via Stabiana is lined with small business places. These include, to the left toward the Vesuvius Gate, a wool worker's shop and a gambling house with rooms of assignation on the second story; to the right, they include an inn, a bar, and a bakery. A couple of turns back in the direction of the Forum lead to the corner of Vicolo del Lupanare and Vicolo del Balcone Pensile, where the city's best-known brothel stands, complete with obscene wall paintings and graffiti. A little southward on Vicolo del Lupanare are found the Stabian Baths, Pompeii's oldest, which retain a nucleus of the original Greek-derived plan with cubicles for individual tubs.

Across Via dell' Abbondanza and down Via dei Teatri is the Triangular Forum, not a forum at all but the precinct of the old Doric temple, with a portico erected in the second century B.C. To the east are two theaters, both set into the sloping incline that continues down to the Sarno. The Large Theater, used for such popular spectacles as rustic farce, mime, and pantomime, was built originally in Greek form, and redone in Roman form under Augustus. It is backed by a large, rectangular colonnade, called a peristyle, originally a promenade for the theater audience, but converted in the city's last years to gladiators' quarters. Farther east is the Small Theater, a once-roofed music hall constructed between 80 and 75 B.C. in Roman style and used for more refined entertainments, such as concerts, lectures, poetry readings, and speeches by rhetoricians.

Above the Large Theater, on Via del Tempio d'Iside, is a small, exclusive gymnasium of the Samnite period, in which a copy of Polykleitos's famous statue of the *Spear Bearer* was found. Next door is the remarkable temple of the Egyptian goddess Isis, the most complete sanctuary of the goddess that remains from antiquity. Her popularity is attested by this temple, the only one totally rebuilt and redecorated after the earthquake. Within the colonnaded court that surrounds the temple itself was a subterranean chamber with a tank for holy water from the Nile. The whole complex was elaborately decorated with mural paint-

Left. This wall painting, once part of a framed rectangular panel set into a complete architectural scheme of a Third Style wall, shows a central porch at the junction of two porticoes. Now in the National Archaeological Museum, Naples, the painting probably depicts a seaside villa. Above. In northeast Pompeii, the enclosed garden of the House of M. Loreius Tiburtinus has a trellis-shaded canal.

1 *Temple of Venus*
2 *Temple of Apollo*
3 *Forum*
4 *Temple of Fortuna Augusta*
5 *Forum Baths*
6 *Triumphal Arch of the emperor Caligula*
7 *Central Baths*
8 *Large Theater*
9 *Small Theater*
10 *Temple of Isis*
11 *Palaestra*
12 *Amphitheater*
13 *Villa of the Mysteries*
14 *House of the Surgeon*
15 *House of Sallust*
16 *House of the Faun*
17 *House of the Vettii*
18 *House of the Gilded Amorini*
19 *House of L. Caecilius Jucundus*
20 *House of M. Lucretius Fronto*
21 *House of the Citharist*
22 *House of the Menander*
23 *House of the Cryptoporticus*
24 *House of M. Loreius Tiburtinus*
25 *Villa of Julia Felix*



1 *Via Consolare*
2 *Via Stabiana*
3 *Via dell' Abbondanza*
4 *Via di Nola*
5 *Vicolo del Lupanare*
6 *Vicolo del Balcone Pensile*
7 *Vicolo di Mercurio*

ings, stucco relief, statuary, and other fittings, many now in the National Archaeological Museum.

Along Via dell' Abbondanza, beginning one block east of Via Stabiana, are the new excavations, where the restored buildings and the street come closest of all to the actual look of ancient Pompeii. Lining Via dell' Abbondanza are shops, one after another, with much writing on the walls. Eight blocks along and one block to the right rises a vast public exercise field (*palaestra*), built in the Augustan period. Beyond it is the beautiful arcuated amphitheater, built just after 80 B.C., for the favorite Roman spectator sport of watching fights to the death between men and men or men and animals. Since the amphitheater was the only secular monument completely rebuilt after 62, it must have ranked in importance with the mysteries of Isis in the lives of Pompeians.

After exploring public monuments, visitors can proceed to Pompeii's houses and gardens. They will find that the earliest houses followed the traditional Italo-Roman plan, each organized around an atrium, a large square room with an opening in the roof to admit rain and a pool in the floor, with a cistern underneath to catch and store rainwater. During the second century B.C., a peristyle was added on the back, with social rooms opening off it. All these houses had gardens, providing both food and natural beauty. More formal peristyle gardens were adorned with fountains and water channels, sculpture and garden furniture, and sometimes a summer dining area under a trellis. The houses were spacious, richly decorated, well furnished, and carefully planned for pleasurable living. Providing well for creature comforts was a great accomplishment of Hellenistic Greeks and their Roman disciples.

Periodically, the mural paintings that decorated house walls changed in fashion. The First Style was not, in fact, a painting style, but a Mediterranean-wide Hellenistic form that imitates real masonry walls of colored stones in painted stucco relief. The Second Style, fashionable from about 80 to 10 B.C., took off on a completely new tack: the painting creates the illusion of architecture, of an exuberantly rich, robust, palatial kind, opening out on the four walls of each room. The Third Style, reticent and genteel, reaffirms the solid wall in flat colors, and reduces the pseudoarchitecture to a network of refined ornament, echoing the decorous, contained neoclassicism that came in with the emperor Augustus. The Fourth Style, which came in after the mid first century A.D. with the emperor Nero, included a number of trends, most of them ingenious, imaginative, and amusing. At its richest, this style reintroduces architectural prospects, but unlike those of the Second Style, they tend to be airy in proportions, fanciful, and fantastic.

Since the better houses are distributed within the city's outer areas, visitors should start at the Herculaneum Gate at the city's northwestern corner, or even better, outside

In a wall painting now in the National Archaeological Museum in Naples, the man handing out bread may be a baker in his shop, or—since he is wearing a toga—a magistrate distributing free loaves

Leonard von Matt/Photo Researchers

the gate, with the Villa of the Mysteries, a handsome country house built in the second century B.C., rebuilt about 60 B.C. with a portico toward the sea, and redecorated at the same time with some exceptionally fine rooms in the Second Style. On the way from the villa to the gate, the road is lined with tombs, as all roads outside the city walls once were. Just inside the gate, on Via Consolare, are two of the city's older houses, first the House of the Surgeon and then the House of Sallust. Both are atrium centered; the latter has the city's fullest surviving complement of First Style walls. On Via di Nola, occupying all of the fourth insula to the east, is the House of the Faun, dating from the second century B.C., one of the largest and finest in the city.

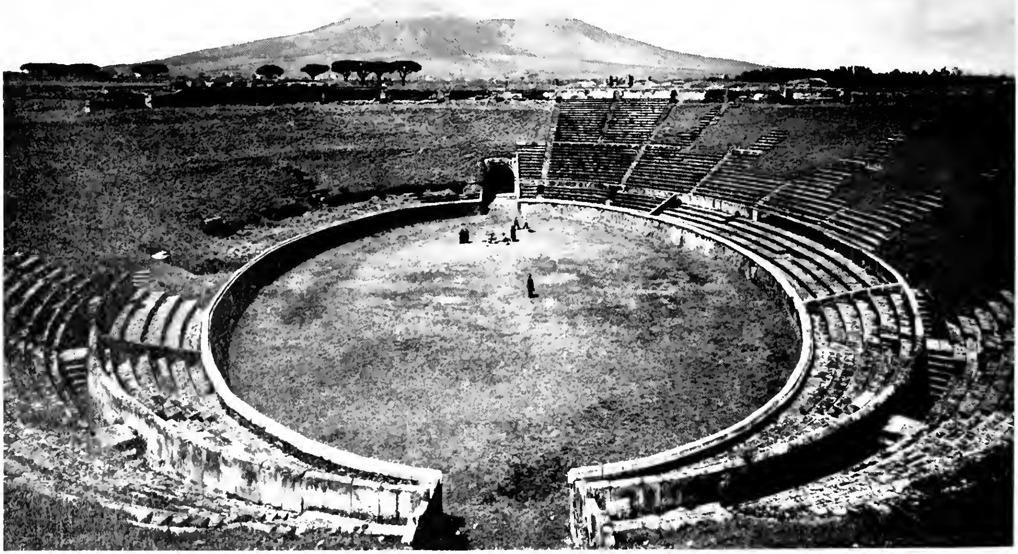
Not to be missed is the House of the Vettii, on Vicolo di Mercurio. One of the few completely rebuilt and redecorated after the earthquake of 62, this house was also the first on which Fiorelli practiced his new procedures, so that it is almost complete, its full complement of mural paintings done in several of the manners of the Fourth Style. In a painting at the doorway, a good-luck Priapus weighs his giant phallus in a scale. The peristyle garden has been restored with plants, sculptures, and furnishings.

Fine Third Style walls can be seen on Via Stabiana in the House of the Gilded Amorini and the House of L. Caecilius Jucundus, and just off Via di Nola, four blocks to the east, in the House of M. Lucretius Fronto. The Caecilius family were bankers, and in their house, excavators found a full set of accounts, as well as a lararium with reliefs depicting the buildings of the Forum toppling during the earthquake, and a remarkably strong, realistic bust of Jucundus's father, Felix—homely, warty, and shrewd.

Visitors should go back to the Via dell' Abbondanza neighborhood for a number of important houses. The House of the Citharist and the House of the Menander are among the largest in the city, with fine decorations and a number of good portraits. They seem to have belonged to two of the most important old families, the Popidii and the Poppaei. The names of the Popidii appear again and again in honorary and dedicatory inscriptions. One member of the Poppaei was Poppaea, wife of the emperor Nero. The House of the Cryptoporticus has unusual Second Style paintings in the four-sided vaulted corridor that gives the house its name, as well as rare decorative stuccoes on the vault. The House of M. Loreius Tiburtinus has one of the most elaborate gardens, with a charming open-air dining room. Another elaborate garden is at the Villa of Julia Felix, which has a number of other attractions. In the last years of Pompeii, this house was rented out in parcels, one of which apparently was used as a brothel. There a provocative little gilded marble statue of Venus and Priapus was found.

Besides the city of Pompeii, conscientious travelers should see the other major Vesuvian sites, all on the beautiful Bay of Naples—Castellammare di Stabia, where several splendid villas of old Stabiae have recently been excavated; Torre Annunziata, which may be the ancient city of Oplontis, where there is one villa with several rooms of excellent Second Style walls, which may have belonged to Poppaea herself; and the six or seven visible blocks of Herculaneum. Finally, the National Archaeological Museum contains hundreds of important and beautiful objects found at all the sites. Because they were found in encapsulated places, they offer the widest, most richly colored spectrum of the types and materials of classical art. ☐

Visitors once flocked to gladiatorial games at Pompeii's amphitheater. The amphitheater's arcuated exterior walls are a particularly beautiful example of the Romans' use of concrete.



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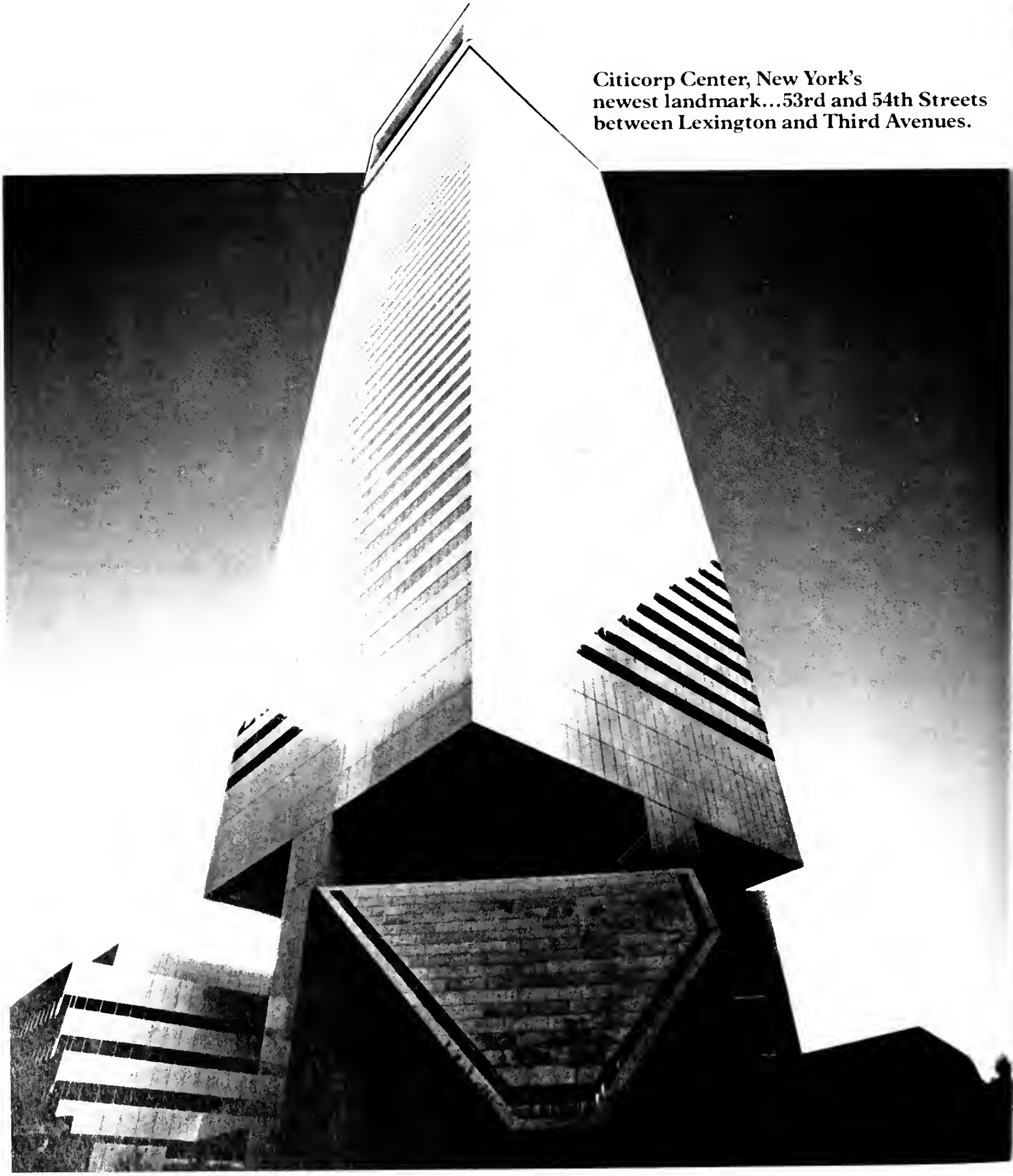

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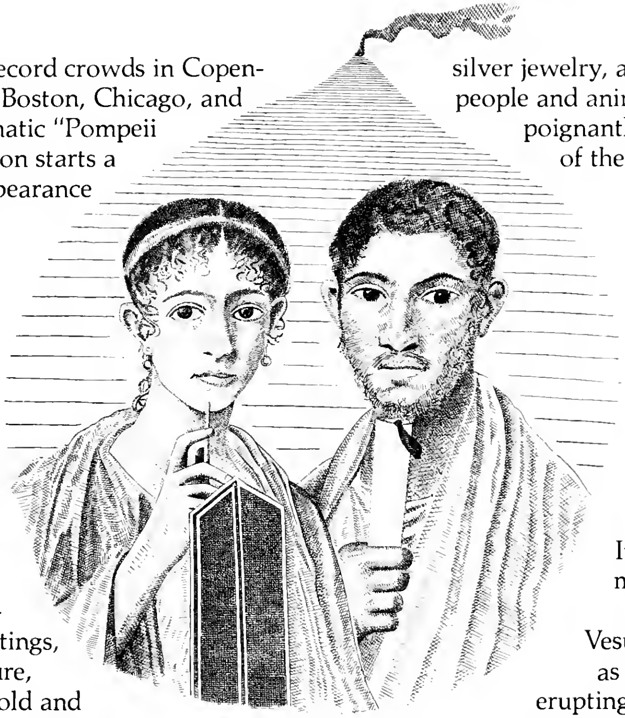

After drawing record crowds in Copenhagen, London, Boston, Chicago, and Dallas, the dramatic "Pompeii AD 79" exhibition starts a three-month appearance at the American Museum of Natural History in April—the final showing before it returns to its permanent location at Italy's National Archaeological Institute.

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Concurrently, "Volcano!" an exhibition prepared by the Museum's Department of Mineral Sciences will be shown. It contains volcanic materials, including lava and ash from Vesuvius itself, as well as films of volcanoes erupting.

The exhibition has been arranged through the cooperation of the Italian Ministry of Culture, and is supported in part through grants from the National Endowment for the Humanities and Xerox Corporation.

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THE HOUSE OF THE FAUN

An aristocratic house in Pompeii reflects Roman thinking about both architecture and society

by L. Richardson, jr.

The house is named for this bronze statuette of a dancing faun, now in the National Archaeological Museum, Naples. A replica remains in the impluvium, a basin to catch rain, of the Tuscanic atrium.

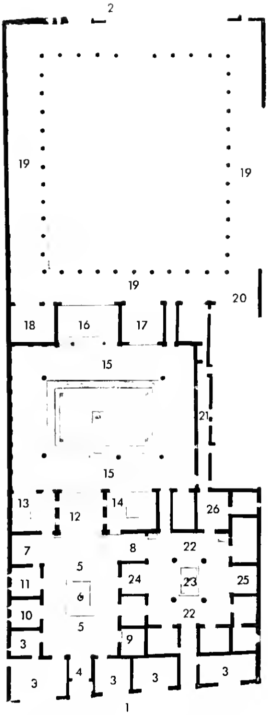
Scala Editorial Photocolor Archives

The House of the Faun, one of Pompeii's most aristocratic mansions, is among the older excavations in the city, and was a particularly unfortunate victim of Allied bombing during World War II. Nevertheless, its noble proportions and deep vistas never fail to impress both casual tourists and serious students of the city. Although the portable treasures that were found in the excavation, as well as a dozen mosaic pavements, have gone to enrich the collections in the National Archaeological Museum in Naples, few visitors can resist photographing the replica of the bronze statuette of the dancing faun that gives the house its name. The House of the Faun shows the patrician taste of a family that had lived here a long time, people accustomed to wealth and privilege, people of conservative habits, but people who looked forward as well as back. Actually, until recently, our knowledge of the house had been based on little scrutiny of its architectural history.

The front block of the house is the oldest part, built about 185 B.C. It consists of two atria, or covered courtyards, and the rooms around them, with a row of shops between these and the street. Originally, only the western atrium was accessible from the street, and there were five shops of more or less equal dimensions. Later one shop was sacrificed to make a secondary entrance to the eastern atrium and give additional space to the shops on either side. When the house was first built, it was a unit, the façade an impressive wall of fine-drafted blocks of warm brown tufa (volcanic ash naturally compressed into stone) trimmed with a Tuscan pilaster between each pair of openings, except at the main entrance to the house, where there were stuccoed jambs with Corinthian capitals and a fine deep lintel. Here the sidewalk's surface of chips of colored stone carried the greeting *have* ("welcome") in big, spindly letters.

Behind this entrance, and on axis with it, was the more important atrium, a great paved courtyard once generously lighted by a large rectangular opening in the center of the roof above a shallow basin, or *impluvium*, that caught the rain. In later houses the rain was drawn off into a cistern under the floor for future use, but in the House of the Faun, it was simply piped out to the street gutter and ran into the city sewers. This atrium is Tuscanic, columnless, to allow a sweeping unity of visual impression. Consequently, the *tablinum*, the great axial exedra beyond, raised a shallow step and framed with massive jambs, dominates the atrium even in its ruined state. The charming bronze faun in the *impluvium* and extraordinary wall decorations in stucco relief imitating stonework, in the First Pompeian Style, did not obscure the apartment's grand proportions. Rigidly symmetrical lines of great doors on either side marched down to the lesser exedrae of the wings and the *tablinum*. Traditionally, the *tablinum* was the most elaborately decorated room in a house. Here only a suggestion of its grandeur is preserved in an uncommonly fine pavement of stone lozenges laid to give an optical illusion of cubes.

Most of the rooms opening off the atrium are small and squarish, but very high, lighted by slit windows to the exterior and by transoms above the doors. These were bedrooms, a storeroom, and a room that served as a lobby between this atrium and its counterpart to the east. Their height is proportionate not to their function but to the doors giving into them, which in turn are proportionate only to the atrium. The whole complex is governed by the axis that runs from the massive house door down the center of the atrium to the *tablinum*. When the house door was thrown open in the morning for the ceremony of the *salutati-*



The House of the Faun

1 *Via della Fortuna, part of Via di Nola*
2 *Vicolo di Mercurio*
3 *Shops*
4 *Main door*
5 *Tuscanic atrium*
6 *Impluvium*
7 *West ala of Tuscanic atrium*
8 *East ala of Tuscanic atrium*
9 *Biclinium, a winter dining room*
10 *Bedroom*
11 *Master Bedroom*
12 *Tablinum*
13 *Triclinium, originally a summer dining room*
14 *Triclinium, originally a winter dining room*
15 *First peristyle*
16 *Exedra of the Alexander mosaic*
17 *Triclinium, a summer dining room*
18 *Triclinium, probably used in spring and fall*
19 *Second peristyle*
20 *Banquet hall*
21 *Corridor of the service wing*
22 *Tetrastyle atrium*
23 *Impluvium*
24 *West axial exedra of the tetrastyle atrium*
25 *East axial exedra of the tetrastyle atrium*
26 *Lobby of the service wing*

At right: North of the first peristyle, Ionic with Doric entablature, are the exedra of the Alexander mosaic and the second, Doric peristyle beyond.

("greeting"), the crowd of the paterfamilias's *clientes* must have been drawn as to a magnet through the splendid portal toward the toga-clad gentleman who awaited them at the end of a carefully calculated vista. (The relationship between a *cliens* and a *patronus* was a peculiarly Roman institution. The arrangement was freely made, and a *cliens* could be a freedman of his *patronus* or could, in turn, be *patronus* to another.)

On either side of the entrance throat of the house are domestic shrines in the form of miniature temple façades, elaborately worked in stucco, triumphs of technique. Underfoot spread elegant pavements, restrained in color, but exquisite in workmanship. During the *salutatio*, all the doors along the sides of the atrium proper would have been closed, directing attention to the far end, where the master's secretaries and clerks occupied the wings, busy with his accounts and records. Meanwhile he himself received in the *tablinum*, listening to the problems of those dependent on him, expediting their business, occasionally summoning a secretary to make notes of the conversation or to prepare a document. He was the adviser, the attorney, the representative for a great many people and in a great many capacities. He arranged marriages, launched careers, counseled on investment, and represented in court. His was a very busy life, and the *salutatio* was only the first act of his day. Once it was over, he had to go to the Forum, to the tables of the bankers and the courts that had their places there or to the curia of Pompeii if the local senate was in session. He would be away from the house for at least the rest of the morning.

As long as the *salutatio* was in progress, most of the family must have been excluded from the principal atrium: it was consecrated to business, and there was too much bustle and confusion for other household work to go on at the same time. In many houses, during the *salutatio*, the family would take refuge in a single big room or, weather permitting, in the garden behind the house. But in the House of the Faun, family members had an atrium of their own that could be entirely closed off from the principal atrium. It had its own main axis on its short dimension and at right angles to that of the Tuscanic atrium, with exedrae to either side in place of the *tablinum* in the main atrium. This pair of pleasant sitting rooms took advantage of the rather intimate and ornamental architecture of the second atrium. This atrium, much smaller than the other, is tetrastyle, with four Corinthian columns, one at each corner of the *impluvium*. Vista was not important here, and the architect was free to make this courtyard gracious as well as useful. Around this atrium were small rooms; most were extensively remodeled later in the life of the house. They served all the varied purposes necessary in great houses: a weaving room, a library, a study. Here the family could pursue its occupations; the mistress could receive her friends and keep an eye on her servants. Apparently, at the time the house was built, no one thought that this atrium should have an entrance from the street; that came later.

Next to the *tablinum* of the principal atrium, the largest rooms in the house were a pair of squarish dining rooms flanking, and only slightly smaller than, the *tablinum*. The eastern room, used in winter, was as tightly enclosed as possible and heated by charcoal braziers. The other, for summer use, had a large window and a door in the north wall to the garden. There was no architectural refinement in these rooms, no particular attention to the use they were to have; each was simply a handsomely proportioned space

Leonard von Matt, Photo Researc

in which the highly portable furniture of the ancients could be set out when needed. For the great ceremony of the Roman gentleman's day at the other end from the *salutatio* was the *cena*, a dinner party canonically for nine guests—although there might be fewer or more—that lasted several hours. Not that they ate all that time—indeed, the Romans throughout their history ate far less than we do and had a very limited, highly seasonal diet based mainly on bread and fish. But they made a social occasion of dinner and, if it was a party, prolonged it with drinking and entertainment. Since wine was virtually their only source of sugar, it was a staple food, as well as a means of giving variety to the meal, and it was commonly changed several times in the course of dinner. Moreover, Pompeii was famous for the quality of its wines. The owner of the House of the Faun probably would have given frequent parties, his guests being his patrician equals, his clients, and freedmen; he would have been proud of his table and his wine, most likely produced on his own estates on Vesuvius's slopes.

Roman aristocratic houses did not yet have the great variety in dining rooms that the Augustan architect Vitruvius prescribes; the owners of the House of the Faun were limited to two, equally grand, the only real difference being in their fenestration. The house plot occupied the whole of its city block, and north from the line of the back wall of the *tablinum*, was all *hortus*, open space planted at least in part with a kitchen garden. In this house there was no kitchen, no latrine, no bath—none of the things we think of as making up the essential core of a house. Cooking was done outdoors in the *hortus*, on a simple hearth platform with bins underneath for charcoal. In bad weather, a temporary shed roof might be set up over the hearth. The latrine was an earth closet that could be filled in and moved when necessary. If the family did not depend on the public baths, they used a bronze vessel that could be stored when not in use. Although the atrium house was a permanent residence, it was not Le Corbusier's "machine for living"; it was an exercise in proportion and volume, designed to show off the master of the house in suitable grandeur.

The Pompeian house is usually said to represent a fusion of two architectural forms, the atrium house of Italy and the colonnaded peristyle house of Greece. But the peristyle house of Greece, rather than a crystallized architectural form, was simply a collection of rooms on a courtyard. And the evidence is strong that the peristyle did not appear in Pompeii before the middle of the second century B.C. The peristyle, as we know it from Pompeii, was probably created there, or somewhere on Italian soil. It was an annex to the atrium, a colonnaded ornamental garden on which living and dining rooms could open with different exposures and to varying degrees, according to the weather and the seasons of the year, and off which could lie subsidiary apartments, a *hospitium* for guests, a service quarter and stables, a dwelling for a married son or an overseer.

The House of the Faun was probably one of the first in Pompeii to have a peristyle added to the nucleus of the original double atrium house. Although handsomely appointed, this peristyle is clumsily planned, a rectangle of twenty-eight Ionic columns supporting a Doric entablature, a common hybridization of the period. The portico is relatively deep, the garden comparatively small, probably a green garden of ivy and shrubs with perhaps a tree or two of moderate size. Flowers were probably potted and changed with the seasons, so there would always be something in bloom; some of the pots may have been sizable tubs, set on blocks sunk in the corners of the garden. Unfortunately, this peristyle was knocked down during the earthquake of A.D. 62 and not rebuilt before the eruption of 79, so it had not been used for many years when Pompeii was overwhelmed. But it contained an interesting collection of garden furniture and ornaments.

The peristyle permitted the *tablinum* and dining rooms of the original house to open onto an ornamental garden, and the owners tore out walls to do so. The peristyle also permitted the introduction of a row of rooms between itself and what was now left of the *hortus*. This row included two grand rooms with garden views in two directions and perhaps a new winter dining room, replacing the remodeled one east of the *tablinum*.

The house now had at least six dining rooms with considerable variety in exposure and size, accommodating both small and large parties. The finest of these rooms, a great exedra on the north side of the peristyle, was paved with the famous mosaic of the battle of Alexander and Darius, now a chief ornament of the National Archaeological Museum in Naples, but only one of a large number of mosaics that decorated the house. Evidently the owners had a penchant for mosaics, and where the adjacent walls were covered with the severe rectilinear blocks and cornices of the First Style, one could see that the decor's effect would have greatly enhanced the handsome polychrome pavements. The architecture of the room in which the Alexander mosaic was installed was uncommonly fine, having jambs with Corinthian capitals and a pair of Corinthian columns on high bases in the opening. Although the architecture of this room and of the peristyle built at the same time shows no

Left: A Fourth Style wall painting from a less distinguished house depicts a dinner party. A drunken guest, at lower right, leans on a companion. Below: This view of the Tuscanic atrium of the House of the Faun looks north toward the tablinum.

sparing of expense, it is not so fine as the architecture of the original nucleus of the house; more was left to the stuccoists to finish, and the proportions and development seem less carefully considered. The peristyle, for example, takes no account of the axis of the Tuscanic atrium and *tablinum*.

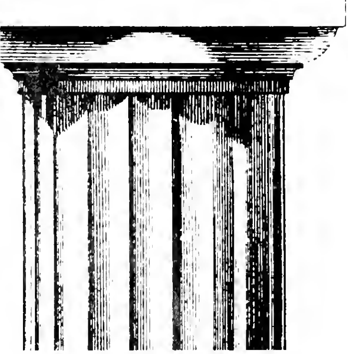
At the time the peristyle was built, the owners of the house decided to organize the various household services in a row of rooms along the east side of the house opening off a narrow corridor just behind the peristyle. No effort was wasted on refinement of these spaces; they are simply a line of rooms, all about the same size, ending with a larger, squarish kitchen courtyard.

The first room was a stable in which the skeleton of a cow was found; the second was the latrine; the third was a bath, heated through a hollow floor and walls and divided into a *tepidarium* and a *caldarium*; the last was the kitchen. Here the hearth is against the east wall and has a window above it; high in the north wall is a house shrine; against the west wall is a cistern head, the draw shaft almost level with the floor. The cistern was supplied from the gutters of the peristyle. Under the south wall is the firebox that heated the bath, and tubular vents for the smoke open high in the wall. The western third of the room was covered with a loft, whose imprint can be seen on the north wall, and the base of the stair that mounted to the loft is in the service corridor. There must have been a fairly extensive second story over this wing of the house.

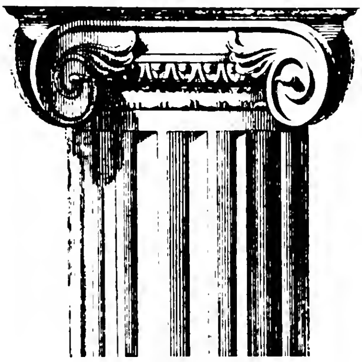
Sixty years or so later, about 85 B.C., the owners decided to convert what was left of the *hortus* into a second peristyle. The open area probably remained a kitchen garden, perhaps even with a bit of grazing for the cow, but was given an architectural definition and a decoration in the First Style. Although the Doric columns are no longer carved stone, but built of terra cotta disks and stuccoed over, the First Style decoration is excellent. Under every wing of the portico are large cisterns; evidently the roof's potential as a rain catcher figured large in the decision to build this peristyle. There is no new bank of important rooms, but the wedge of space made by the deviation from a true rectangle at the north end of the block became a series of shallow alcoves, a closet, a storage cellar, and a room for the keeper of the back gate. The most interesting of these spaces is a little stage for private theatricals in front of which one peristyle column was removed so the audience, gathered in the open area as well as in the portico, would have an unimpeded view. This was a late improvement, certainly no earlier than the time of Augustus, perhaps no earlier than Nero.

Second-story rooms are found in various parts of the house, but except for those over the service wing, they all appear to be late modifications, in each case limited to a single room or two. Certainly the front part of the house, except for the shops, was originally all a single-story structure of noble scale. Hence, archeologists are surprised to find numerous elements of a second-story Ionic colonnade piled along the east wall of the second peristyle. There are too many elements—belonging to some fourteen or fifteen columns at least—to be there by chance, yet this portico certainly could not have had such a second story above it. Besides, these elements are all carved in Nocera tufa, while the columns of this peristyle are constructed of terra cotta disks.

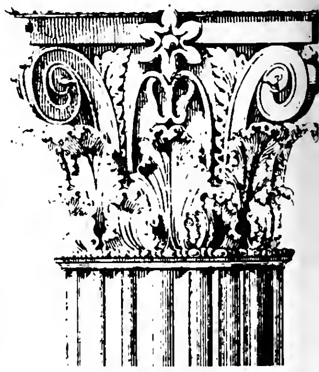
The solution to this enigma occurred to me only recently: these second-story elements belong in style to the second period of the house, not the first. They ought to belong over the wing between the first and second peristyles, where they would have made a *cenaculum*, a loggia for use as a summer dining room, open to the evening breezes from the slopes of Vesuvius. This loggia could have been accessible from the one section of second story that appears genuinely old. In the earthquake of 62 the first peristyle and the rooms north of it were badly damaged. In the years that followed, the owners were unable to find the necessary workmen and artisans, the specialists they needed to restore fine mosaics and decorations that were already two hundred years old. They were prepared to wait, and at the time of the eruption in 79, workmen were just beginning to lay a new limestone curb around the peristyle. Meanwhile, the Alexander mosaic was in danger of deteriorating, so the owners dismantled almost everything in this wing but the Alexander exedra, shored up its walls and roof with big masonry buttresses, and constructed a rough wooden porch out in front. And that is how the elements of the second-story loggia came to be lined up where they are today; they were put there to await the rebuilding that never came. □



Doric capital from the second peristyle



Ionic capital from the first peristyle



Corinthian capital from the tetrastyle atrium

From *Le case ed i monumenti di Pompei*, Fausto and Felice Niccolini, German Archaeological Institute, Rome

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LIVELY LAST DAYS AND NIGHTS

In Pompeii, out-of-towners could find lodgings and amusements to match meager or lavish finances

by James Packer

Pompeii lies just under fourteen miles southeast of Naples. The modern tourist, using either bus, auto, or suburban train, can travel between these two cities in well under an hour, but the inhabitants of Campania—the ancient name for the area around the Bay of Naples—found the journey more formidable. Setting out from Pompeii, a man on foot needed an entire day to reach Naples, while a horse and carriage required a little more than half that time. Consequently, a trip to Naples was something out of the ordinary for those who lived in the territory watered by the Sarno River, and for these people Pompeii was the chief metropolis.

Pompeii's ancient tourists were of every class and social condition. The rich owners of luxurious villas, which dotted the surrounding countryside like so many domed and pillared villages, visited friends and shopped for luxuries produced in the city's busy workshops. Merchants arrived with their wares. Itinerant artisans executed commissions in mosaic, sculpture, stucco, or paint for wealthy clients. Lovers followed their hearts. Traveling troupes of actors played local engagements. Soldiers, temporarily detached from their units, passed through. The pious offered sacrifices at urban temples. Citizens of neighboring communities attended games in the amphitheater. Even slaves from the countryside came to Pompeii to run errands for their masters, who were either prosperous farmers or the owners of aristocratic villas.

Such travelers approached the city by means as varied as their classes and circumstances. The rich traveled in great state. When not in a hurry, they used litters—roofed, curtained, sometimes even windowed. Small litters needed only two bearers; large ones required eight. Reclining at ease inside, the occupants slept, read, or watched the scenery. Alternatively, the prosperous traveler used either a large four-wheeled wagon, drawn by four or more horses, with space for a number of passengers and luggage, or a light two-wheeled equipage pulled by a pair of fast horses. Sometimes a rich man used litters for himself and members of his family, wagons for the slaves and baggage. The less affluent rode horses or mules—and the poor walked.

Whatever their means of transportation, visitors in early summer A.D. 79 would almost certainly have been impressed by Pompeii's appearance. Built astride a prehistoric flow of lava that ended abruptly as a scarp above the Sarno, not far from its mouth, the city had heavy walls of finely drafted tufa and limestone blocks, strengthened at intervals by twelve rectangular towers. Although neglected for more than a century and a half, these walls were still in relatively good condition, and most of the gates retained their heavy fortifications. Only to the south and the northwest had the walls disappeared under a group of elegant mansions whose successive stories, terraced down the ridge on which the town stood, took advantage of excellent views across the countryside.

In a detail from a first-century A.D. mosaic, musicians enlivening a street in Pompeii may also be actors; the woman playing double pipes wears a theatrical mask. The small figure behind her may be a child or a dwarf. The two dancing men play castanets and a tambourine. Found in a private house in Pompeii, the mosaic is now in the National Archaeological Museum in Naples.

As travelers neared the end of their journey, however, they must have been thinking less of the view than of their night's lodgings. Aristocrats faced no serious problems. They and their entourage would stop with family friends in either a suburban villa or an urban mansion. There they would find all the luxuries they took for granted at home: a set of private hot and cold baths to wash away the dust and grime of the journey, a *familia* of obsequious slaves to supplement personal attendants in catering to every need, an opulently furnished house with artfully arranged gardens. In some, bronze and marble statuettes and skillfully contrived fountains and canals still beguile tourists.

Commoners and the less affluent—then as now a majority in Italy—had no such social connections and arranged for their own accommodations in one of the city's inns. Fortunately, these establishments were not hard to find. Arriving through one of the principal gates—the Sarno Gate to the northeast, the Herculaneum Gate to the northwest or the Marine Gate to the southwest—visitors immediately found themselves on a main street. Irregular blocks of gray volcanic stone formed the pavement, and on both sides, raised sidewalks fronted low, two- and three-story buildings, all stuccoed and brightly painted, many in strong reds and whites. Wooden balconies gave upper apartments excellent views of the bustling crowds below, while shops occupied the lower stories. Each shop's wide, rectangular door opened directly onto the public thoroughfare, and many had signs announcing their trades to passersby: a bakery, a cleaning and dyeing workshop, a poultry stall, establishments kept by barbers, gold and silver smiths, hairdressers, wheelwrights, carpenters, masons, or smiths specializing in bronze, copper, and iron. With good reason, one anonymous businessman scrawled, "Hail gain!" on a wall near his place of work. Near the main gates of the city, many shops sold wine and food. Sought out by locals and visitors alike, these classical delicatessens were centers of neighborhood gossip where an inquirer could pick up useful tips on where to spend the night.

The typical wineshop was both busy and cluttered. Entering through the usual wide door—closed at night by wooden shutters and a heavy bolt—patrons found themselves in a small, low, dark room. An L-shaped counter partly filled the door. Embedded in the counter were two or more large terra cotta jars used for storing grain, nuts, dried or smoked fruits and vegetables, the simple items normally served with wine, along with sausages and cheese. Wooden racks attached to walls and ceiling supported the long, graceful, two-handled amphorae used for storing wine. At one end of the counter, where it adjoined the wall, were steplike shelves to display small glass dishes of food.

The counter's other end served as a cooking table, or hearth. Here, as in all such facilities, the cook first kindled a fire on top of the hearth and allowed it to burn down to coals. Then, to support utensils, the cook set small triangular or rectangular grills with miniature feet on top of the coals. Often a wineshop had a rear kitchen where lead containers were sometimes built into the walls, with space left underneath for heaping coals. These containers heated water, often mixed warm with the wine. Normally, the walls of the shop were white, set off by a high red dado. But the fussy, cluttered furnishings made up for the simple decor. Hanging oil lamps of bronze or terra cotta cast a smoky, fitful light. A typical example in bronze assumes

A wall painting from an inn shows two men at dice. The inscription over the head of the player at right reads, "Three not two," referring to throws of the dice. The painting is now in the National Archaeological Museum in Naples.

the shape of an ithyphallic humpbacked pygmy with several additional phalli and hanging bells attached. On the front counter, the innkeeper often set small ceramic pitchers fashioned in the forms of birds or animals. In many shops, the clients must have crowded about the counter or lounged in front of the shop door. But the better places had back rooms where customers sat on low benches around three-legged tables.

Here one of the patrons would be sure to offer the newcomer a tip on where to stay, and not infrequently, the host himself had a rear or upstairs room he rented out. But wineshops had a deservedly bad reputation, and the needs or tastes of travelers might prompt them to look elsewhere for lodgings. If they had a wagon and horses, they tried to find a *stabulum*, like the one a block east of the Forum. Here a passage wide enough for carts led from the street to a central court, where the innkeeper stored his guests' wagons and served communal meals from an adjacent room fitted up as a kitchen. Windowless bedrooms, the more expensive accommodations, lined the court, and there were upstairs dormitories for poorer patrons. There was a special room for the porter just by the entrance to the court, and a single latrine in the rear served the entire establishment.

More prosperous travelers without cumbersome carriages stopped at better quality inns, such as the *hospitium* on a quiet street just off Via dell' Abbondanza, one of the main east–west boulevards. This establishment offered its patrons a number of amenities, chief of which was a large private bar. The ground floor had a secluded dining room, several bedrooms, and a small, outdoor dining area, equipped with permanent masonry dining couches and enlarged visually with garden scenes painted on the walls. Here an impressive stack of amphorae, still partly embedded in volcanic *lapilli*, suggests the large amount of wine consumed on the premises. Upstairs, there were several small bedrooms at the front of the building and a back dormitory reached by a stairway from the kitchen.

So pretentious an inn was probably equipped with furnishings like those found in the homes of the wealthy. The bar may have boasted a wooden *lararium* like that found in the House of the Carbonized Furniture at Herculaneum. That piece is divided into two sections: the one above, a low shrine flanked by miniature Corinthian columns, sheltered statues of the household deities; the lower section, divided by shelves, stored small vases and dishes. When the assemblage was not in use, four paneled wooden doors concealed each section from view. Like all Roman rooms, the bar would have been lighted by lamps that burned olive oil. Such lamps were frequently used in some numbers, suspended from hooks attached to bronze lamp standards reminiscent of modern hat racks. Two- and three-legged tables of wood, marble, and bronze would have completed the room's furniture. Dining rooms were equipped with special low couches, usually of wood with bronze fittings and headboards. Mattresses, sustained by wooden slats and ropes, were stuffed with wool and covered with brightly embroidered bedspreads in elaborate designs. The bed in each sleeping chamber, while similarly constructed, resembled a high modern couch, enclosed with boards on three sides and reachable by a small, portable set of steps.

Whatever its furnishings, every inn was a lively place. Contemporary paintings from these hostelries show patrons informally attired in light tunics, sitting at tables where they are being served by waitresses or small boys. Some wear pointed traveling hoods, most hold glasses or terra cotta cups. Graffiti — which suggest a widespread literacy among the lower classes — provide the names, occupations, and interests of these former clients. In one inn, a certain Vibius Restitutus complained of sleeping without "his Urbana." Three actors from the company of Actius Anicetus used the same room, which at another time housed C. Valerius Venustus, a soldier from the first praetorian cohort. The walls of an adjacent chamber recorded the temporary presence of C. Iulius Speratus, from Puteoli, today known as Pozzuoli, and Lucceius Albanus, from the neighboring

onard von Matt Photo Researchers

town of Abellinum (Avellino), slept in a nearby room.

But drinking, not sleeping, was the primary occupation of most guests, who could order several kinds of wine—"Vesuvium," "Pompeiana," and "Falernian"—from Campanian vineyards. The last was the most expensive. As one graffito explains: "For a single *as* you can drink here; if you pay double, you may drink better; if you pay four times the amount, you can drink Falernian." Another graffito suggests that groups of friends apparently imbibed together: "Hail, drinkers! . . . When you came, we paid our bill." The innkeeper frequently added water to the wine, and in one captioned painting, a patron holds out his long, conical cup to the attendant and asks, "Give me just a little drop of cold water." But not every customer was pleased with watered wine, and another graffito records one customer's bitter dissatisfaction: "May your lies fail you, landlord! You sell the water and drink the good stuff yourself."

Inns offered more than drink: some guests preferred to gamble, staking everything on the chance of a "Venus" or a "Royal"—lucky throws of dice. Others watched dancing girls or consorted with the barmaids, who frequently doubled as prostitutes. Customers scribbled the names of their favorites on the walls: Sittia, Maria, Calpurnia, Smyrna, and Palmyra; the last two perhaps exotic foreign slaves from the Greek East. According to one set of paintings from an inn, intimacies between customers and barmaids sometimes resulted in full-scale orgies. But even if the host did not offer his girls' favors to his guests, there were always nearby brothels and neighborhood prostitutes. Of course, drinkers, gamblers, and womanizers were not the most staid of patrons, and one graffito begs for tranquillity. When polite requests went unheeded, the host had to be firm. One painting shows a landlord pushing a quarrelsome pair of customers out the door. The caption above his head reads, "Beat it! Quarrel outside!"

Apart from the diversions offered at various lodgings, visitors had two chief sources of recreation in Pompeii: the baths and the games in the amphitheater. In fact, a famous Roman saying ranked the former with wine and women as one of the chief pleasures in life: "Baths, wine, and women ruin our bodies, but they make our lives worthwhile!" There were two main sets of baths at Pompeii: one near the Forum; the other, three blocks away at the corner of Via dell' Abbondanza and Via Stabiana. A third set, three blocks north of the latter, was under construction at the time of the eruption.

Doubtless everyone had a favorite spot, but the arrangement of all these establishments was similar. At the Forum Baths, there were separate sections for men and women. The men entered either through the pillared exercise court off Vicolo delle Terme, a narrow side street, or from Via delle Terme, on the opposite side of the building. Women had their own private entrance. Both men's and women's sections had four parts: a dressing room, a lukewarm bath, a hot bath, and a cold plunge.

The chief hours for bathing were usually from two to three o'clock in the afternoon. Undressed and well rubbed down with oil, the bather began with exercise—ball playing, running, hoop rolling, or for men, wrestling. Then a hired bath attendant scraped the oil and dust from the bather's body—the rich had their own slaves to perform this service. The bather next proceeded to the lukewarm bath, then the hot bath. Bathing ended with a return to the cold tank for a final plunge.

Besides providing workouts and soaks, the baths were crowded meeting places where idlers passed whole days. Nero's tutor Seneca, who in his less prosperous youth once lived above a public bath, complained bitterly of the various typical noises: the grunts of a weight lifter in the exercise court, the slap of a masseur's hand against the well-oiled skin of his client, the commotion attendant on the arrest of a drunk or a pickpocket, the shrill cries of the sausage seller and the hair plucker, and the racket caused by that perennial nuisance, the man who sings while taking his bath.

Toilet complete, the visitor emerged from the noisy bath to seek amusement. Gladiatorial games offered the town's most spectacular diversions. On walls throughout the city, painted signs announced the shows: "Twenty pairs of gladiators will fight at Pompeii April 8, 9, 10, 11, and 12. There will be a big hunt and awnings." Attracted by such notices, everyone flocked to the amphitheater, a large oval stadium, partly sunk into the ground, with space for at least 20,000 spectators.

Having reached the seats from vaulted subterranean passages underneath the grandstands or from one of the several external stairways, the audience settled down under the shade of vast awnings to a varied program that lasted nearly all day. The main events started in the afternoon with a parade, which included the president of the games and the gladiators. The latter saluted and filed back into the passages below the grandstands to await the sound of a trumpet, their signal to fight. Engagements often opened with mock battles, but the real combats began to the music of horns, flutes, and trumpets.

Gladiators, trained to fight in different styles with various types of armor, took their names from the armor they wore. Thus a *murmillo*, who wore a special helmet crowned with a fish, fought a *retarius*, a man armed only with a trident and a net (to ensnare his opponent). Thracians and Samnites took their names from the national style of their armor. A bout customarily continued until one combatant was wounded. Then the injured man could either fight to the death or appeal to the president of the games for mercy. The president almost always followed the wishes of the spectators. Sometimes, if the suppliant had acquitted himself well, the mob proved merciful. More often it was not, and cries of "get him!" "slash him!" "he's wounded!" filled the amphitheater. The program of games continued in like manner until all advertised pairs of gladiators had fought in the arena.

Thoroughly gratified by this bloody spectacle, Pompeians and visitors alike streamed out of the amphitheater in the dusk. Pompeians returning to their homes, visitors to their lodgings. There, according to their inclinations, visitors could spend a night of sober rest or of drinking, gambling, or wenching. Early the next day, most set out for home, probably well satisfied with the treatment they had received and doubtless intent on returning as soon as possible.

In the city, landlords of the recently vacated inns were directing their slaves to set empty rooms and dormitories to rights. New shipments of wine, delivered in large steer-hide containers mounted on four-wheeled carts, were arriving. In the baths, slaves were relighting the furnaces for the day's customers. In the pillared court behind the town's theater, gladiators began practicing their exercises. Thus each day—until August 24, A.D. 79—Pompeii readied itself for its next round of visitors.

The men's bath in Pompeii's Forum Baths

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PRESENTING POMPEII

The exhibition "Pompeii AD 79" was arranged through the cooperation of the Italian Ministry of Culture and is supported in part through grants from the National Endowment for the Humanities and Xerox Corporation

by Ann Marie Cunningham

In the exhibition **"Pompeii AD 79,"** opening at the American Museum of Natural History on April 22, a black-and-white floor mosaic depicts a rather clumsy skeleton holding a wine jug in either hand. This bit of popular Pompeian art expresses the *memento mori* precept of Epicureanism, introduced to Rome in the second century B.C. All too appropriately, the mosaic reminds us that in the midst of vinous life, Pompeii's citizens were caught by death.

But conversely, in death they live on. The exhibition includes casts of a young woman who was found face down, trying to protect her head with her tunic, and an agonized watchdog on its leash. Both seem to have met their terrible ends very recently. Because life stopped abruptly, leaving the city frozen in a frame of daily life, Pompeii is important to natural history and volcanology, history and art history. It provides evidence of the most destructive of Vesuvius's known eruptions. This particular "disaster movie" was real and has been repeated in that area on a smaller scale during our own century.

The eruption halted history's progress in Pompeii before economic crises could make serious inroads into the urban plan and way of life. To the extent that a provincial agricultural center can reflect the Roman Empire's principal city, Pompeii has bequeathed us much of our knowledge of Rome. Pompeii, unlike Rome itself, was never subjected to repeated urban renewals, which are death to valuable archeological evidence.

The rich who came to Pompeii—many enjoyed splendid views over the Bay of Naples from their luxurious houses around the town—were also patrons of artists and artisans. The middle class and even those in humbler circumstances commissioned mosaics for their homes and decorated their walls with paintings of mythological subjects, landscapes, and details of the good life: a silver wine bucket, a plate of figs. The exhibition includes both construction workers' tools and the products of glassblowers, bronze workers, potters, goldsmiths, silversmiths, painters, stuccoists. It also reflects economic reality and pleasurable living in jugs for both olive oil and wine from groves and vineyards on the fertile slopes of Vesuvius.

Most of the objects do not match our general impression of classical art. We normally think of such art as occupying a calm, serene gallery in art history, where the cool white of marble and the dignified blacks, dark browns, and greens of bronze sculpture and vessels express spirituality, detachment, gravity. Actually, Roman objects were polychrome. Some of the graceful figures and naturalistic animals found in Pompeii still bear part of their original bright paint. Marble busts were dark eyed, the tipsy elderly woman had red lips. The bathing Venus pictured on a poster advertising the exhibition retains traces of a gilded, bikinilike harness. Part of the base on which she stands is still green. In particular, Pompeii's houses, with their wall paintings, allow us to appreciate Roman art in its original rainbow variety.

"Pompeii AD 79" has already traveled to the Boston Museum of Fine Arts, the Chicago Art Institute, and the Dallas Art Museum, and objects from Pompeii have been seen in various European cities. But the National Archaeological Museum, Naples, which houses most of these pieces, cannot display a great many of them; it has had to close many galleries until funds become available for needed repairs.

Over the past ten years, various collections of the museum's embarrassment of riches have traveled to Japan and several northern European cities, including Paris and Ge

Corinthian column detail from Pompeii's basilica, from François Mazois's Les ruines de Pompeii

German Archaeological Institute, Rome

neva. Impressed, a British cigarette company decided in 1975 to sponsor a similar exhibition at London's Royal Academy, and invited John Ward-Perkins, a historian of Roman architecture who is now Great Britain's foremost classicist, to arrange the show.

Besides his academic expertise, Ward-Perkins had been for twenty-six years director of the British School in Rome, and after World War II, he had helped Naples's National Archaeological Museum recover parts of its collections that had fallen into German hands. Consequently, he and his assistant, Amanda Claridge, felt that they were in a strong bargaining position. As Claridge explained, "We would ask for things we thought were just within reason, and ended up with objects we never dreamed we'd get." Claridge and Ward-Perkins needed patience and some time—until April 1976—to obtain Italian permission to borrow the beautiful things they wanted, including fragile mosaics and wall paintings vulnerable to any vibration or change in temperature.

When the show closed in London in early March 1977, it had attracted 636,000 people, including staff members of the Boston Museum of Fine Arts, whose director, Jan Fontein, had already seen and admired an earlier, similar exhibition in his native Holland. Ward-Perkins put in a good word for Boston with Italian authorities. To obtain funding from the National Endowment for the Humanities (matched by Xerox) to bring the Naples pieces stateside, the Boston Museum invited the Chicago Art Institute to participate.

When these museums, later joined by the Dallas Museum, applied to the federal government for indemnification of the show, Thomas D. Nicholson, director of the American Museum, was a member of the council that reviewed such applications. Struck by the quality of the objects from Pompeii, Nicholson contacted the Boston Museum and arranged to see the show at Copenhagen's Louisiana Museum. At this archeological museum, Nicholson was convinced that objects of so much archeological and ethnographic significance should appropriately visit the American Museum.

At Boston, Chicago, and Dallas—art museums all three—the Pompeian objects were displayed to be appreciated for their beauty. Since the show includes jewelry, cookware, tools, and erotic and religious art, the American Museum plans to supply additional information and, whenever possible, to arrange the artifacts so that they reveal something of the lives of the people who wore, used, or appreciated them. There will also be a peristyle garden with a fountain, under a luminous ceiling simulating sunlight.

"Pompeii AD 79" will be on display in the Museum's Gallery 3 until July 31. It will be open to the public and Museum members on Saturdays and Sundays from 9:00 A.M. to 5:00 P.M. Until June 15, Mondays through Thursdays, mornings will be reserved for school groups; on those four days, others can view the exhibition from noon to 5:00 P.M., and on Fridays, from noon to 9:00 P.M.

After June 16, exhibition hours on Mondays, Tuesdays, and Thursdays will be 11:00 A.M. to 5:00 P.M.; on Wednesdays and Fridays, from 11:00 A.M. to 9:00 P.M. Although the Museum's hours for school groups have been completely booked, a small number of adult groups can still be booked for Friday mornings by calling (212) 873-6004.

All tickets are free with Museum admission. Museum members can order tickets in advance. Tickets for the public will be available every day at the Museum. Each ticket, valid only on the day of issue and at a specific time, will have a number that will appear on television monitors, stationed around the Museum, when the ticket holder's turn comes. This method of ticketing gives the Museum the option of varying the exhibition's capacity if a rainy day attracts fewer visitors—and also forestalls hoarding, scalping, counterfeiting, and other nefarious practices, which have been the true mummy's curse accompanying the "Treasures of Tutankhamun."

While waiting for their numbers to come up, visitors can see a free film program in the Auditorium. One short film covers the workings of volcanoes; the second, the actual sites of Pompeii and its sister city, Herculaneum, which is still mostly buried. There will be four screenings of the two films on Mondays, Tuesdays, Wednesdays, and Thursdays; five screenings on Fridays, when the Museum will be open until 9:00 P.M.; and six screenings on Saturdays and Sundays.

Near the Auditorium, in Gallery 77, just off the Museum's West 77th Street entrance, will be "Volcano!" a companion show to "Pompeii AD 79." Tickets to the Pompeii show also entitle visitors to embark on "Volcano!"'s encapsulated journey to the earth's interior. "Volcano!" will greet visitors with a large mass of lava from Vesuvius and will attempt to describe the formation and activity of volcanoes.

Martin Prinz, chairman of the Museum's Department of Mineral Sciences and scientist for "Volcano!" says the show's point of view is that "volcanoes are good for us," in that they are essential to life on earth because they create air, water, and land. The exhibition will use a combination of film, artifacts, specimens, photographs, and recordings of the sounds of an erupting volcano. Among other points, it will explain how calderas form and show the differences between a shield volcano such as Mars's huge Olympus Mons, which rises 90,000 feet, and a composite volcano such as Vesuvius. Shifting lights will create the illusion of an erupting volcano; slide dissolves will demonstrate the principles of plate tectonics; and there will be photographs of Mount Pelée's eruption in 1902.

—When Pompeii comes to the Museum, there will be accompanying events through July. From May 3 through September 3, the Planetarium show will be **The Last Nights of Pompeii**, seen from the point of view of a modern family learning about the disaster, and in flashback, by a group of Pompeians the day before the eruption. Kenneth Franklin, who wrote the script entirely in dialogue, met the obstacle of the Romans' lack of interest in astronomy by having a Greek slave explain the skies to the Pompeian household. The ancient and modern voices will be accompanied by slides and a simulated eruption.

—A series of Wednesday evening programs will take place at 7:30 in the Auditorium. Each admission will be \$5.00, \$4.00 for members. On Wednesday, May 2, Eugene D. Stavis, director of the American Cinematheque at the Metropolitan Museum of Art, will introduce the 1935 version of ***The Last Days of Pompeii***, by the director of the original *King Kong*. This program will be repeated, same time, same place, on Wednesday, May 30.

—On Wednesday, May 9, Robert Rosenblum, professor of art history at New York University's Institute of Fine Arts, will present a slide lecture entitled ***Vesuvius to Apocalypse in Romantic Art, 1760–1914***, and discuss

the treatment of Vesuvius and Pompeii in romantic art.

—Wednesday, May 16, will be devoted to the May membership program. At 7:30 P.M. in the Auditorium, Martin Prinz will expand his article on page 40 of this issue into a slide lecture on the natural history of volcanoes entitled **Volcano!** The program is free to members, $2.00 for the public.

—On Wednesday, May 23, archeologist Anna Marguerite McCann, an experienced excavator at Pompeii, will present a slide lecture entitled **Pompeii AD 79/New York 1979**, a discussion of the Museum exhibition.

—During May, there will be two special **Crafts Workshops**. On Saturday, May 19, participants will learn mosaic design and construction and will be provided with materials to make a small panel. The workshop will run from 11:00 A.M. to 4:00 P.M. Enrollment is limited to 18 persons. The cost of the workshop is $40.00

—On Sunday, May 20, there will be two slide presentations and participatory demonstrations (1:00 to 2:30 P.M. and 3:00 to 4:30 P.M.) on fresco and wall painting. Enrollment is limited to 20 persons per session. The cost is $6.00. For more information, call (212) 873-1300, extension 559.

—Future Pompeii events during June and July will be announced. They may include a program of Roman comedies that played Pompeii and Herculaneum. Meanwhile, in the **Pompeii Shop**, Museum visitors can purchase the two-volume catalog to "Pompeii AD 79" ($4.50 per volume, $8.00 for both); children can find a puzzle of a mosaic of sea life still fished in the Bay of Naples ($2.75), and a kit for assembling a handsome peristyle house ($4.25).

Leonard von Matt Photo Researchers

Mosaic of sea creatures from a house in Pompeii (National Archaeological Museum, Naples)

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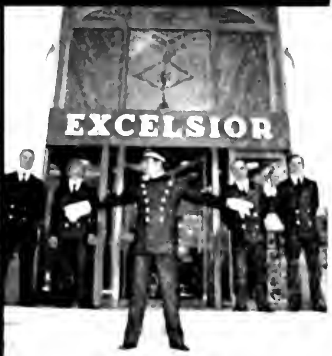

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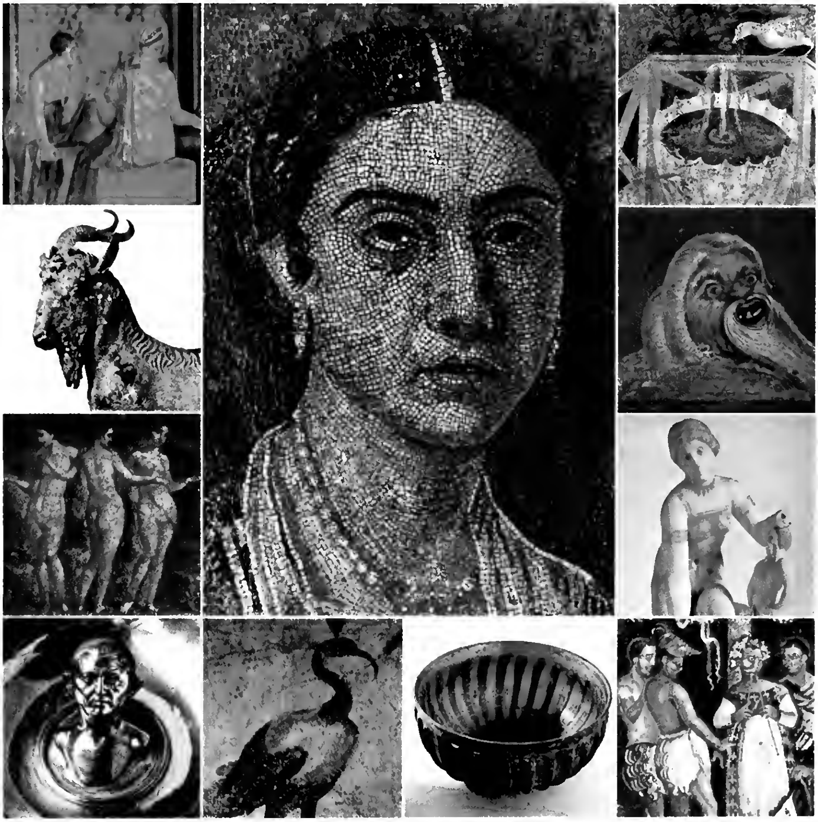

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Vesuvius destroyed Pompeii. And saved it at the same time.

This exhibition is made possible by grants from the National Endowment for the Humanities and Xerox Corporation.

POMPEII AD 79

American Museum of Natural History

April 22 through July 31

XEROX

Eleonora's Falcon

by Hartmut Walter

Migrating European songbirds must fly through a gantlet of falcons to reach their African wintering quarters

European falcons were well known centuries ago. Their habits, migrations, and changing plumage were described in great detail in the literature on falconry. An outstanding example is the famous treatise *De arte venandi cum avibus*, by Emperor Frederick II of Hohenstaufen (1194–1250). This book is a marvel of keen field observation and critical scientific thought. Frederick discusses and describes nearly all of Europe's falcon species, their color phases, and their juvenile, immature, and adult plumage. Yet he fails to mention Eleonora's falcon.

The oldest reliable reference to this species comes from a falconry treatise by Charles d'Arcussia de Capre, published in 1627. This author mentions hobbylike falcons breeding in August on the "iles d'Or" (today called Iles d'Hyères) off Provence. These falcons chased birds but failed to capture them. "They are useless and have no courage at all." This remark is an outgrowth of the utilitarian attitude of the author: in his opinion, this type of falcon could not be used for any purpose related to falconry.

Knowledge about this falcon did not reach naturalists and scientists until the Italian zoologist Guiseppe Gene published a description of Eleonora's falcon in 1839. This date will forever be connected with the entry of this species into modern ornithology. The Italian naturalist and historian Alberto della Marmora had discovered what he thought was a new species of falcon on the small isle of Toro, southwest of Sardinia. He shot several specimens and sent them to his friend Gene in Torino. Marmora wrote that Gené presented a scientific description of the new species during a session of the Royal Academy of Sciences of Torino on May 5, 1834. This means that Marmora must have discovered the birds on Toro not later than the 1833 breeding season. Gené's official description, however, was not published until 1839.

The new falcon species received the name of one of the few famous women of the fourteenth century, Eleonora of Arborea (ca. 1350–1403), who had distinguished herself as a military leader, regent, and judge of a large part of her native island of Sardinia. Her most important work is the *Carta de Logu*, an unusually progressive code of laws published in the Sardinian language in 1392.

Gene named the new falcon after Princess Eleonora because her *Carta de Logu* contains a paragraph providing for the protection of falcons and hawks, and to honor her for "her admirable wisdom in the century of barbarities in which she reigned to protect the honor, the life and the goods of the people." Thus *Falco eleonorae* became the first European bird named after a woman.

Eleonora's falcon is an inhabitant of the islands of the Mediterranean basin. Only in the western part of its range does this raptor extend into the cooler Atlantic habitats of northwest Morocco and the Canary Islands. All its current or formerly known breeding colonies lie along the Europe-Africa boundary from the Canaries in the west to Cyprus in the east. Immature and other nonbreeding falcons are occasionally found considerable distances from the seashore and from their native colony. This raptor has been observed in all countries bordering the Mediterranean Sea, but not north of the Alps.

Eleonora's falcon is not evenly distributed throughout its breeding range, but occurs in a rather irregular geographical pattern, primarily on small islands. Some of its breeding colonies are within sight of neighboring ones, but some are hundreds of miles away from any other colony. This irregular dispersion is the result of two geographical phenomena. First, the many islets and islands of the Mediterranean are unevenly distributed over the basin; they cluster in large groups in the Aegean Sea, but only a few exist in the western part. Second, Eleonora's falcon breeds only on high cliffs or on top of a rocky isle's substrate. Such habitats do not occur on many miles of coastline around the Mediterranean and adjacent Atlantic.

I have yet to see a breeding site of Eleonora's falcon that would not be worthy of a picture postcard—towering cliffs on jewellike islands in the blue or green Mediterranean. Mallorca is typical. While tourists hastily take snapshots of the jagged rock formations at the Punta de la Froneta, beneath the vantage points of Cabo de Formentor, several Eleonora's falcons are likely to be chasing each other up and down the pale limestone cliffs in a fantastic display of aerial acrobatics. Because of the height of the cliffs, however, they can hardly be seen without good binoculars, and their characteristic calls mingle with the crashing of the surf and the exclamations of tourists.

Other colonies lie on small offshore isles. The two classic breeding spots of this species, discovered by Alberto

Reprinted from *Eleonora's Falcon: Adaptations to Prey and Habitat in a Social Raptor*, by Hartmut Walter. By arrangement with The University of Chicago Press. © 1979 by The University of Chicago. All rights reserved.

della Marmora, are the small rocks of Vacca and Toro, off the coast of Sardinia, scarcely visible in the haze and glare of the Mediterranean summer. Many Aegean colonies have been reported from similar offshore rocks that hardly classify as isles: rather, they constitute a hazard to navigation and more often than not offer only dangerous landings. On such islets Eleonora's falcon does not necessarily prefer to breed on the steepest cliffs. The vertical cliffs, or *falaises*, offer few nesting spots and are generally exposed to the prevailing winds. Eleonora's falcon prefers somewhat protected and sheltered nesting places, but continued harassment and predation seem to force the species from such preferred sites to safer habitats on steep cliffs.

Of the many Greek isles named Paximada, Paximadi, or Paximadia, the one on which I studied a breeding colony of Eleonora's falcons lies off the northeast part of Crete; Athens is about 200 miles to the northwest. The island is only 3,300 feet by 2,000 feet and rises 395 feet. Its shoreline is deeply dissected by numerous ravines. The upper edge of the steep west coast also forms the ridge of the island. From here the surface slopes gently to the east, where there are only a few precipitous cliffs. In many spots the surface consists of loosely piled, often sharp-edged rocks, resembling a large heap of rubble. According to my Greek friends, the word *paximada* is used for the dry bread eaten by Crete's peasants. You have to break it up into pieces, then soak them in water; otherwise the bread is as hard as stone. This island probably looked to the Greeks like their shepherd's bread.

The island environment mirrors the general ecosystem of the eastern Mediterranean coast. Mild, rainy winters and warm to hot and dry summers characterize the annual cycle. There is a strong contrast in temperature and humidity between wind-exposed and sheltered, sunny and shaded areas of Paximada. This was apparent at once to this human attempting to live for some time on this heap of rubble. The physical environment is affected by two main factors: sun and wind. The wind blew relentlessly during my study period; there were only five calm days among fifty. The sky was often clouded, and the wind generally came from the northwest, part of the *meltemi* storm system that has a strong cooling effect on the Aegean coasts.

To evaluate this colony's adaptation to the spatial and resource factors of its macroenvironment, we must examine the structure and dynamics of the annual migration of millions and millions of prey birds attempting to cross the Mediterranean.

As soon as winter cold, ice, and snow recede farther north, Europe is invaded each year by millions of small passerine birds belonging to some one hundred different species. Most are insectivorous birds that use the long summer days and the abundant insect food supplies of central and northern European habitats to raise one or two broods before leaving Europe again at the end of the summer. The late British ornithologist Reg Moreau made the guess that, "on the average, from every five acres of Europe one trans-Sahara migrant sets out for Africa." This figure means that some 5,000 million will attempt to cross the Mediterranean/Atlantic and the adjacent Saharan desert barriers.

Another wave of migrants, the millions of birds that will spend the winter months in the Mediterranean and North African areas, crosses over parts of the Mediterranean/Atlantic later in the fall. There is some overlap of these two groups of migrants, and Eleonora's falcon captures some passerines of the second group, although its bird quarry consists principally of trans-Saharan migrants.

Depending on their points of departure and flight direction, these warblers, orioles, shrikes, and other migrants face a grueling journey. The Mediterranean Sea is up to 620 miles wide (Ionian Sea). Narrow sea crossings can be made near the Strait of Gibraltar, the Sicilian Channel, and the Bosporus, but, except for diurnal migrants such as raptors and storks, few migrants appear to take advantage of such favorable factors of Mediterranean geography. The average migrant crosses several hundred miles of sea. When it arrives in North Africa, few food resources await it in late summer and fall. This may partially explain why some migrants appear to fly

Eleonora's falcon has two color phases. This mated pair, consisting of a light phase female and a dark phase male, are perched over their nest, which is hidden from view below the euphorbia plant.

not only across the sea but also across the subsequent 900 to 1,400 miles of the Sahara in one nonstop crossing. Depending on the force and direction of the wind, the average passerine migrant will need forty to sixty hours of flight time for such a journey.

The smaller passerines appear to travel commonly at air speeds of about 25 mph. Fast-flying birds such as quails, turtledoves, and swifts have been clocked at much higher speeds, and radar observations of such migrants have proved their higher average speed per unit of time. The speed generated by the bird will be its actual travel speed during calms. Calms were rare, however, when I studied Eleonora's falcon in various parts of the Mediterranean. At Paximada, winds near ground level were very strong on many days. During the fall months most winds seem to come from a more or less northerly direction and are therefore likely to increase the travel speed and shorten the total time needed for crossing the water barrier between Europe and Africa. Their considerable force amounted to 12 to 30 mph. The wind velocity could therefore have added 50 to 100 percent of a migrant's own travel speed to the effective migration speed when the wind was favorable.

Most sea crossings between a southernmost European departure point and a North African arrival point cover some 220 to 300 miles. During calms the average migrant (25 mph) would need 8.8 to 12 hours for such a journey. However, the longer sea crossings, particularly those over the Ionian Sea, require some 18 to 28 hours of nonstop flight under such conditions. These flight times are reduced when a moderate to strong breeze from dead astern adds some 12 to 30 mph to the migrant's own speed. For a crossing from the southwest tip of Greece to Cyrenaica, only 6.7 and 4.4 hours would be needed (instead of 10 hours during a calm). A strong breeze from the north

Having captured a songbird to feed his family, a male is set to transfer the prey to his mate who waits with beak agape. The female, all her feathers erect in excitement over the meal, resembles a balloon.

would enable a south-flying migrant to cross the Mediterranean under cover of night except for the Ionian Sea area.

Banding records indicate that each species has a preferred migration route from Europe to Africa. Individual birds sometimes repeat a nearly identical itinerary for several years, since they have been recaptured in the same trapping location. The migration course of the nocturnal migrants appears to be genetically fixed, that is, certain navigational information that the bird is able to absorb and "read" from the environment permits it to correct its flight direction in order to reach the species' traditional wintering area. Most of the trans-Saharan migrants fly at night and rest during the day if favorable habitat conditions permit. Everywhere in the Mediterranean basin, migration sets in with a surprising regularity some 45 minutes after sunset. The radar images of coastal peninsulas and capes appear to actually merge into the sea at this time because of the large number of bird echoes received from migrants moving from the coast over the sea. The density of migrants may vary in a spectacular manner from hour to hour, creating a "migration pulse." From the falcon's point of view, such a migration pulse is of great importance.

New, largely radar-acquired knowledge about the nature of nocturnal bird migration above the Mediterranean basin is significant in our attempt to better understand the raptor-prey system that involves both Eleonora's falcon and so many species of migrants. Paximada's location at the southern edge of the Aegean Sea determines the time period during which a strong migration pulse can be felt. The Cyclades and the Greek mainland deprive Paximada of significant numbers of daytime migrants except during the early morning hours. This time, however, constitutes a prime falcon hunting period because north of Paximada there is a considerable expanse of open sea: at least 100 miles separate the islet from the larger islands of the Cyclades. This means that all migrants that are between 10 and about 100 miles to the north or northwest of this falcon colony at sunrise find themselves flying over open sea. Radar evidence suggests that these birds continue their southward migration until they reach land. They constitute the main supply of potential prey for the Paximada falcons. The falcons first encounter those migrants that are close to Paximada at sunrise. The last arrivals in the Paximada airspace would be slow-flying birds needing almost four hours for the sea crossing between the Cyclades and Paximada. They would arrive at Paximada about 9:30 A.M. This coincides well with the observed period of prey arrivals at the Paximada colony. The number of bird prey carried to each nest dropped off sharply after the first three morning hours.

Noon and afternoon hunting activities of Paximada-based falcons are usually directed to the occasional diurnal migrant of small size (swallows, wagtails, waders). At dusk, falcons may chase those few migrants that have spent a day of rest on Paximada and are now taking off again. The numbers involved are insignificant, however, compared with the mass of broad-front migrants that pass over the island during the early morning hours.

As with other falcons, there is a division of labor between male and female during the breeding season. The female guards the young and the nest territory carefully almost twenty-four hours a day. She also plucks the prey and feeds small pieces of it to the chicks until they can do it themselves.

Carrying a willow warbler received from her mate, a female is just about to hop or fly to the nest to feed their young. Most songbirds are captured in the early morning hours.

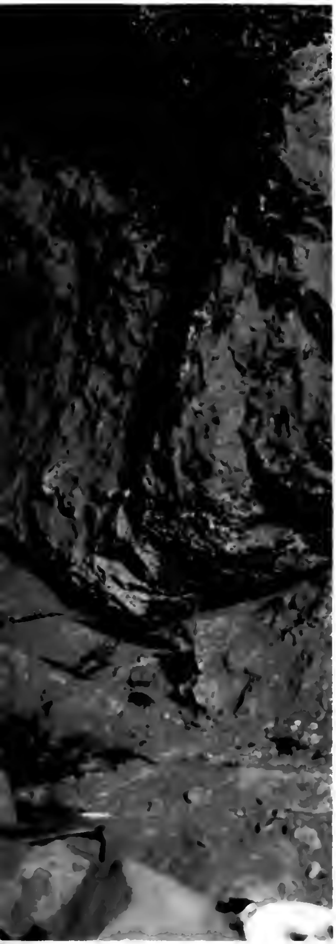
Ristow

Hartmut Walter

Chicks are guarded by their mother until they are about two weeks old. After that age, both parents hunt for food, and a chick is capable of plucking the prey and tearing it into swallowable bits.

The male is the hunter who supplies food to the whole family. In families with chicks of two weeks and older, both parents may hunt, even simultaneously. My observations at various nest sites lead me to believe that females hunt the same type and variety of bird migrants as males do.

Migrating passerine birds are usually hunted in the airspace over the



Brooding her young, a dark-phase female avoids incubating one of her eggs (which proved to be infertile). Eleonora's falcon plucks its prey before feeding; hence nest sites are always littered with feathers.

open waters and near the shores of the Mediterranean Sea and the Atlantic Ocean. This characteristic seems to be shared by every colony; Eleonora's falcon also hunts right above its colonies on small offshore islets. The colony practiced "standing flight" in large numbers over Paximada. In this typical hunting technique a falcon flies head-on into the wind but does not move relative to the ground. Its tail is not fanned and its wings are mildly bent, making 160 to 200 wingbeats a minute. In spite of this nearly normal forward flight behavior, the falcon effectively does not move because the forward-propelling force of its movements is equal to the backward-driving force of the air current; the two forces neutralize each other so that the falcon literally remains hanging in the same position relative to the ground. Falcons can maintain standing flight for at least ten to fifteen minutes. A fairly constant field of vision is generated that enables the raptor to detect the movements of potential prey items more easily.

The standing flight provides a waiting and lookout position during the hunt. The falcons simply wait somewhere in the airspace until a prey object approaches. As soon as a falcon recognizes a migrating bird of suitable size in its field of vision, it tries to reach the migrant as quickly as possible. There were more falcons standing above 2,500 feet than at lower altitudes of 2,000 or 1,000 feet. From every point of the island I could see about twenty-five falcons in the sky. Each falcon kept a distance of about 330 to 660 feet from all its neighbors. Thus, during the early morning, when nearly all of the one hundred fifty males were hunting simultaneously, there was a broad, high barrier to bird migration in the air north of Crete; from sea level to 3,000 feet above it, several miles wide and deep, there existed a unique live bird trap, the "Paximada falcon wall." It is the extreme form of gregarious hunting in this species.

A good way for me to detect bird chases over Paximada was to watch for sudden zigzag flights and clusters of falcons going through loops, stoops, and so on. Migrants were generally not visible above several hundred feet, but when they were chased, tiny white flashes beamed from the sky every second or two because their light-colored undersides reflected the sunlight during evasive maneuvers.

The first falcon to attack usually attempted to fall upon the migrant from high above, thus increasing its speed and impact. Most migrants responded by quickly dropping down a bit, arresting their flight, or flying an irregular, zigzag pattern. As more falcons attacked from the sides and from behind, the migrant lost even more of its flight altitude. It tried, however, to continue its flight, since it could not seek shelter in the rough sea below. The more attacks a migrant had to repel, the lower was its flight level; finally, although it had escaped all its pursuers so far, a new attack would make it accidentally touch the water. Apparently shocked by the whole experience, it would begin to lose control and was usually caught seconds later.

Should the migrant escape the first attack, the falcon would turn around and try its luck again; in the meantime, however, other falcons that had been on nearby lookout positions and had observed the first chase might join in the hunt. Thus the same migrant might be pursued and attacked by three, five, even ten to twenty falcons in short sequence. The victim of this combined hunt would gradually wear out and slow down, and it might finally be captured by a falcon that was attacking for the first time. A falcon unaccompanied by other members of its colony would usually give up a chase after three to eight unsuccessful attacks.

Group hunting was not an organized event but was more opportunistic in nature. If other falcons saw each other's potential prey, they simply converged upon the migrant as each falcon tried to grab it.

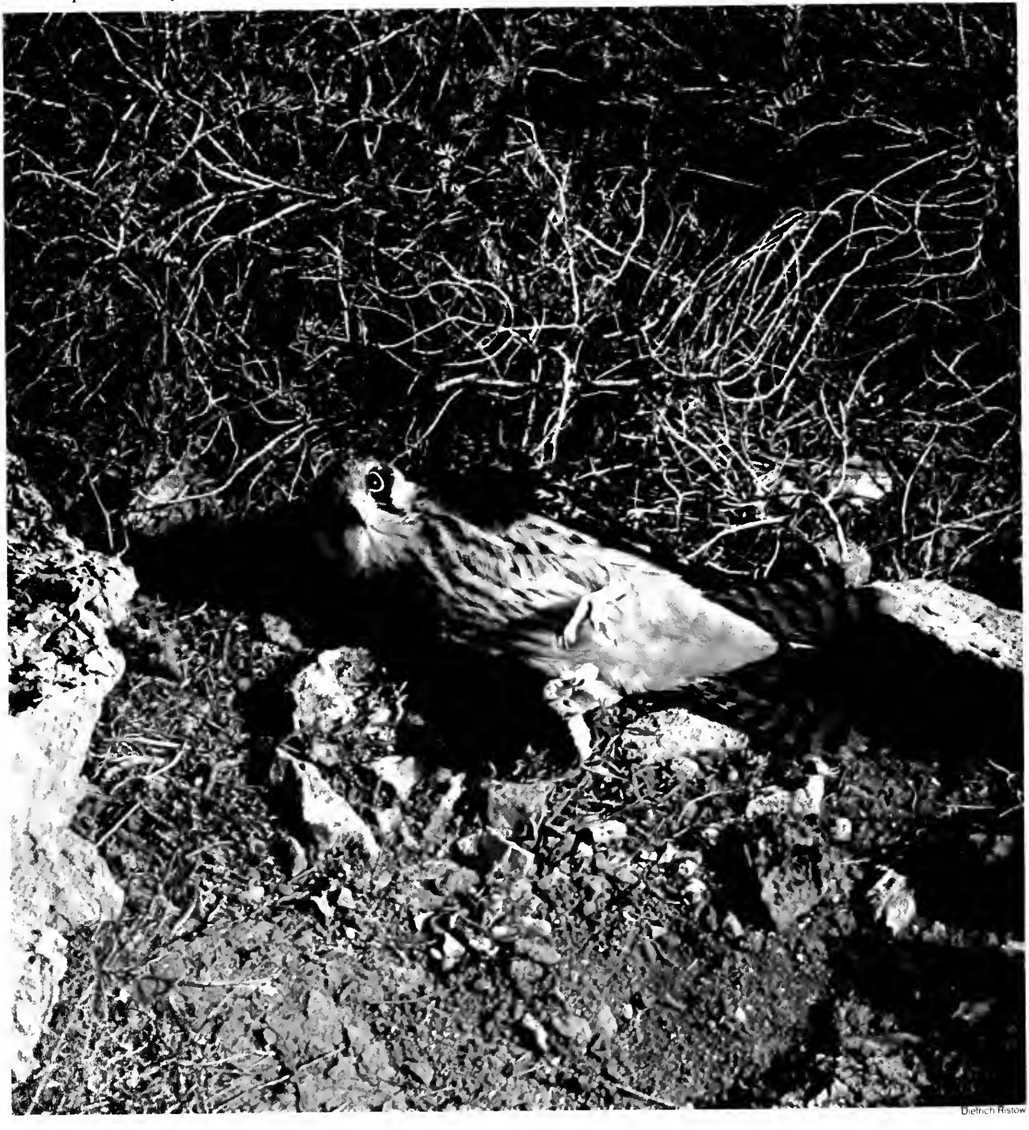
Considering how long the falcons need to fly to and from their lookout positions, it is amazing that they can catch more than one bird per hour during the early morning peak hunting period. I often saw a falcon male carry three migrating birds to his family within sixty minutes. The Paximada record observation was when a male caught five birds between 5:37 and 6:12 A.M. The same male captured seven more birds within the following four hours. Such observations mean that some falcons can hardly have been in the air for more than a few minutes before capturing a migrant.

Hunting can also succeed without the standing flight technique. Undoubtedly some hunting took place at wave level. Other hunting techniques might have been employed but escaped my attention because of their infrequency. Some migrants approached or left the island during times when most falcons had already completed their daily hunting. They were discovered by perching falcons or by those that had been gliding about the cliffs. A number of these raptors immediately set out in hot pursuit. Some migrants were also accidentally met by falcons returning from insect hawking over Crete or perhaps simply from an unsuccessful hunting period.

Lying on his back and flashing his talons, a young, light-phase male Eleonora's falcon assumes a defense posture. The bird is about four weeks old, and predation by owls is a threat.

Many small migrant birds passed through the airspace over Paximada unharmed. They even managed to survive the flight through the main zone of the falcons forming a broad, high barrier with their standing flight behavior. Unfortunately, I did not collect a great deal of data on hunting success; often I merely noted that a chase was going on without finding time to follow it and determine the fate of the intended prey. Offhand, I would say that more than 50 percent of the pursued birds managed to escape even the onslaught of several falcons. Once they had survived a chase for some 2,000 to 3,000 feet horizontally and changed altitude to a safer level (where there were few falcons on lookout positions), they were usually out of danger.

The shape, size, and color of prey objects is not genetically predetermined in great detail among the genus *Falco*. Individual falcons will modify their prey preferences in accordance with their hunting success. Captive falcons can easily be trained within a few weeks to prefer a new prey species over



Dietrich Ristow

all others. Thus, acquired preferences result in a selection by individual falcons of certain prey species that will be hunted more often than others, irrespective of their numbers or population density.

While no bird appears to be too small for Eleonora's falcon, birds the size of turtledoves, cuckoos, scops owls, and European nightjars constitute its upper limit in prey size. Its frequent coinhabitant of coastal rock habitats, the rock dove is often a target of pursuits and (mostly playful) attacks but rarely shows up in a list of prey species. This pigeon appears to be too heavy and perhaps too strong and fast for the average Eleonora's falcon. This raptor is also not well suited to chasing swifts. In the colonies I studied, the three species of swifts (common, pallid, and the large alpine swift) proved difficult, usually unattainable prey. The swifts' mastery of flight and their incredible speed make them generally superior to a pursuing Eleonora's falcon. More often than not, I observed swifts flying unchallenged through the airspace of a falcon colony.

The majority of Palearctic migrants consist of small to medium-sized, slow-flying passerines that live on the ground or in shrubs or trees. When they become discernible to a human observer at a distance of more than 500 feet, it is usually impossible to distinguish the species or genus. Wagtails and orioles are exceptions. Although equipped with superior sight, Eleonora's falcon also must initially receive only one piece of information—small bird flying at low speed ahead. In effect, most of these passerines appear out of nowhere at a similar speed and in exactly the same hunting habitat. They probably all constitute one prey type to Eleonora's falcon, with complete disregard for species identity. The competitive nature of this raptor's hunting is an additional factor weighing against selective hunting of this migrant group. A falcon has no time to wait to make out the genus or species because other falcons take over the potential prey in those few seconds. My observations confirm this hypothesis. Whenever I monitored falcons on hunting flights, they went after any small migrant passing close to their own position, except for swallows and swifts.

The small migrants that happened to pass right over a falcon colony employed a number of flight maneuvers to escape one or several falcons. Sometimes a migrant escaped by landing at the falcon colony itself. Here on the cliffs, in caves, holes, or in the dry shrubs covering the island, these birds were at least temporarily safe. I watched some of them attempt to take off from this inhospitable refuge in broad daylight. Yellow wagtails and hoopoes were among the species. Usually they were captured or driven back to the island by the falcons. In general, once a migrant landed on Paximada it would remain there until dusk or nightfall, staying in the shrubs near the ground and flying as little as possible.

Some birds were so frightened by the presence of so many falcons that their behavioral response was quite different from their normal antipredator behavior. Once, when walking to my observation post, I saw a large red bill protruding from a small cleft. It was a Eurasian golden oriole hiding from the falcons. This bird nests and feeds in the canopy of European forests. To my knowledge it never enters any hole or crevice in its breeding habitat. And I once saw a hoopoe pressing itself against a vertical cliff for at least thirty minutes, moving only its head. This extreme antiraptor response was very functional since it made the migrant inconspicuous. Whenever migrants followed one or several of the above unusual tactics they had an excellent chance of leaving the falcon colony unharmed during the following night.

Because of migration patterns, Eleonora's falcon preys predominantly on just a few species. The total migration density and number may therefore be less relevant than the numbers of the dominant prey species. Unfortunately, few, if any, estimates exist of the total migration population of such birds as shrikes and warblers. Analysis of prey data suggests that shrikes make up more than 10 percent of the falcon's bird diet. This would mean that the estimated world population of 4,400 pairs of Eleonora's falcon would take well over 100,000 shrikes out of the migration. Such figures may come close to one percent of the total population of a dominant prey species.

There can be little doubt, however, that the impact of Eleonora's falcon on bird migration as a whole is negligible. We can probably safely state that the falcons capture on the average fewer than one out of every thousand migrants. Such a predation rate is insignificant when compared with the other factors that affect the prey species' perilous migration from Europe to their African winter quarters. □

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The Once and Future Planetary Rings

Some speculation concerning the prevalence of this phenomenon within the solar system

More than fifty years elapsed between the discovery of Saturn's rings in 1610 by Galileo and the correct interpretation of what they were by Huygens, the Dutch astronomer and physicist. From that time until just two years ago, the Saturnian rings were considered to be unique in the solar system. With the discovery of the rings of Uranus in March 1977, Saturn seemingly lost its uniqueness, but the ring systems of the two planets appear to be quite different.

Saturn's rings are principally two broad bands, easily visible even in a small telescope. They are believed to consist of a myriad of small, centimeter-sized snowballs made of contaminated water ice. The rings of Uranus, on the other hand, are inconspicuous narrow bands (at least nine in number), which were detected only by means of sophisticated astronomical techniques. They seem to be made of fewer and possibly larger particles, which are definitely not snowballs since they are black. According to recent estimates, the ring particles of Uranus reflect less than 5 percent of incident sunlight. In contrast, those of Saturn are believed to reflect 60 percent or more.

Is it possible that all giant planets once had rings? This question is raised because Saturn's rings may be nearing the end of their existence. Planetary scientist James Pollack of NASA's Ames Research Center has calculated that the rings' ice particles are being eroded away on time scales that are short—hundreds of millions of years—in comparison with the age of the solar system—about 4.5 billion years.

The particles are being chipped away by a process known as sputtering, rather than being lost by evaporation. The latter is ineffective because the temperature of the ring particles is so low—about 90° K, or −297°F—as measured by infrared radiometry. At

such temperatures ice is essentially stable against ordinary thermal evaporation even if evaporating into a near vacuum such as space.

In sputtering, a particle hits a surface with enough energy to knock out one or more molecules in billiard-ball fashion. The colliding particle can be a micrometeoroid, an electron, or a photon—anything with a lot of energy. In Saturn's vicinity, sputtering is due to micrometeoroids, to the electrons and protons making up the solar wind, and even to ultraviolet photons from the sun.

Obviously, the rate at which ring particles are being destroyed is difficult to estimate with great accuracy, but they *are* being whittled away and will not last forever. On the basis of radar echoes and other radio data, the ring particles today are believed to be a few centimeters across on the average. Thus, according to the estimated erosion rates, the particles are shrinking rapidly and must have once been much bigger than they are today. Pollack estimates that erosion processes at the orbit of Saturn have been powerful enough to remove ice balls as big as many meters in diameter since the solar system formed.

We may therefore be looking now at the heavily abraded cores of much larger original snowballs, and perhaps witnessing the final stages of life for Saturn's rings. If this is so, it is reasonable to ask whether other planets have previously had rings and also whether Saturn has always had rings.

On the latter point, Pollack has suggested that Saturn's rings may have formed rather recently, perhaps millions of years ago, but will not last much longer. Various schemes have been proposed for the formation of rings in the recent past. First, it is possible that a large icy object (either a comet or a satellite) happened to stray

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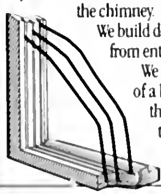

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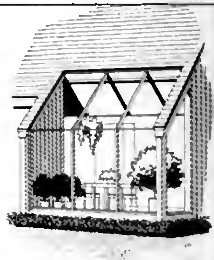

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so close to Saturn that it was pulled apart by the planet's tides. Second, there could have been a collision of two such objects near Saturn. In either case, at distances close enough to Saturn, the differential tidal pull of the planet would be greater than the mutual attraction of the pieces of debris; the fragments would then separate and never re-form the big object. The distance within which this phenomenon occurs is called the Roche limit, and in the case of Saturn it is about two planetary radii (72,000 miles). In other words, the rings seen today lie within Saturn's Roche limit.

It is more common, however, to argue that the rings of Saturn are "primordial," that is, they took shape at about the same time as the planet and the rest of its satellites. According to this view, residue—probably in the configuration of a disk—was left over in the planet's equatorial plane following Saturn's formation. The material in the disk outside the Roche limit could, and did, accrete and grow into large satellites. Within the Roche limit a large satellite could not accumulate and the material remained in the form of scattered debris—the rings visible today.

If all major planets originally started out with material left over within their respective Roche limits, then all would have had ring systems early in their histories. The fact that some major planets no longer show these rings could be explained by the proposition that the particles have by now been virtually eroded away or, alternatively, have been destroyed by some other mechanism.

In the case of Jupiter, the largest of the planets, a powerful removal process can be invoked. There is good evidence, both theoretical (derived from models of Jupiter's evolution) and observational (based on the change with distance from Jupiter in the chemical composition of the planet's four big satellites, those discovered by Galileo), that Jupiter went through an early, very luminous phase, in which for the first several million years it was much hotter than it is today. At that point in its evolution Jupiter was collapsing under gravity, thereby radiating a large amount of heat, which increased temperatures in the planet's vicinity relative to those found today.

For now, the sun is the only important external heat source in the neighborhood of the Galilean satellites, whereas earlier, Jupiter also delivered

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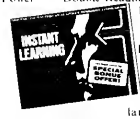

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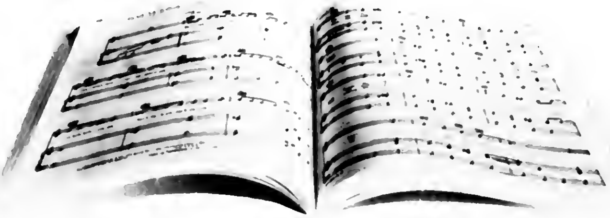

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significant amounts of energy. The chemical compositions of the Galilean satellites suggest that temperatures within the Roche limit of Jupiter were so high that water ice (as well as other ices, including frozen ammonia and methane) would have vaporized, thus accounting for the lack of rings made up of icy particles around Jupiter today.

Although the temperatures in the vicinity of Jupiter were hot enough to vaporize ice, they were almost certainly too low to vaporize rock. Since the hypothetical ice particles surely contained some rocky material, one must therefore wonder what happened to this component. If the rocky component consisted of very small particles—one centimeter or less in diameter—such material would have been removed by the so-called Poynting-Robertson effect, the drag produced by the pressure of sunlight on tiny grains, which in this case makes them spiral gradually into Jupiter. In addition, the lethal radiation in the Jovian Van Allen belts, which threatened the viability of the Pioneer spacecraft, may have destroyed the larger particles.

One can in this manner explain the current absence of a ring system for Jupiter, even if rings were initially a common feature of all major planets at the time of their origin. However, the idea that *all* the outer planets started off with icy rings involves serious dilemmas. It is far from clear that the Jovian mechanism would work for a planet such as Neptune, which is much smaller than Jupiter and is not believed to have gone through any substantial overluminous phase during its early evolution.

Therefore, while the absence of such rings from Jupiter can be understood, it is difficult to argue that Saturn has not yet destroyed its rings although Uranus and Neptune have already eliminated the icy components of theirs. Since Uranus and Neptune are much farther away from the sun than Saturn is, the sputtering discussed above is expected to be less severe in their vicinity than near Saturn. We cannot be sure whether Neptune has a ring system at the present time. It certainly does not have one as prominent as that of Saturn, yet it could have one as inconspicuous as that of Uranus. Future occultation observations, such as those used to discover the rings of Uranus, may resolve the issue.

Although Uranus does have rings, they are unlikely to be made of ice

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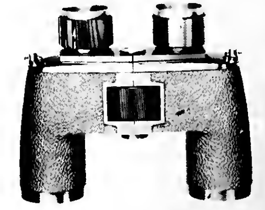

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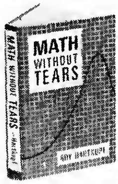

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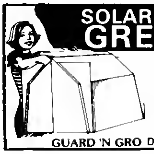

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since, as mentioned earlier, the particles are very dark. There is no reason to suspect that Uranus had as luminous an early history as did Jupiter, or to claim that Uranus, but not Saturn, got hot enough to boil away the ice of its ring particles. Accordingly, if it were true that all major planets were originally surrounded by icy rings, it is very difficult to understand why Uranus and Neptune are not surrounded by such rings today. One suggestion is that perturbations from Mimas, the nearby Saturnian satellite, trap the ring particles, thereby accounting for their unusual longevity.

Another possibility is that all ring systems are short-lived, at least on the time scale of billions of years. In this model, Saturn and Uranus have rings now only because they were produced recently from the tidal disruption of a body that by chance strayed too near the two planets. In this view, the material in the Uranus rings is dark and not icy because the parent body that fragmented may have been made of carbonaceous chondrites—a common composition for non-icy small bodies at distances from the sun greater than about 2.5 astronomical units (an AU is the mean radius of the earth's orbit, about 93 million miles).

The possibility that ring systems may be forming, and even disappearing, on time scales of less than five billion years, while possibly startling, is not absurd. Although it seems static on the human time scale, the structure of the solar system is evolving.

Even though Neptune may not have a ring system today, we may, with some certainty, predict that it will probably develop one in the next 100 million years. Of Neptune's two unusual satellites, Nereid and Triton, only the latter is important for our story. It is the innermost and evidently a large satellite, almost certainly bigger than our moon. Triton is in a retrograde orbit, that is, it revolves around Neptune in a direction opposite to the rotation of the planet. This is an unstable situation. It was shown in 1966 that Triton is spiraling into Neptune and will crash into the planet within 100 million years or so. On its way in, the satellite will probably be broken apart by tidal stresses from Neptune, and fragments of what once was Triton will then ring the planet. Mutual collisions among the fragments will grind down the original pieces and produce a whole array of particle sizes, some large but many small. These will survive for a moderately long time—hundreds of million to billions of years—and give Neptune the most magnificent rings that any planet in our solar system has ever had.

The formation of planetary ring systems by the destruction of satellites close to their parent planets may not be an entirely uncommon process in the evolution of the solar system. For example, Mars may also be on its way to becoming a ringed planet. Its innermost satellite, Phobos, is known to be orbiting Mars faster than the planet rotates. This means that, like Triton, it also is being pulled into its parent planet by tides. Within 50 to 100 million years Phobos should disappear, either falling into the planetary surface or breaking up beforehand because of the differential pull of Martian tides.

Phobos is already within the Roche limit of Mars, but since it is a solid body, it is still strong enough to resist

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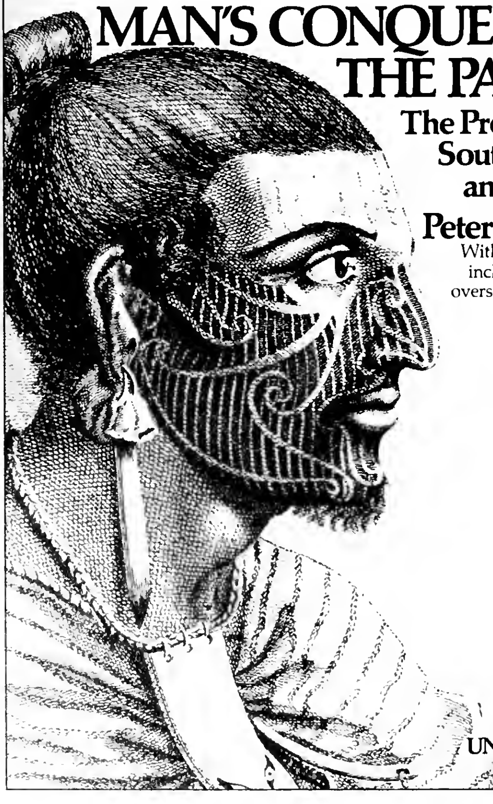

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the tidal forces. From the Viking missions, we know that Phobos is made of a material similar to that found in carbonaceous chondrites, which are easily fragmented and very dark. One can predict that Phobos will indeed break up into innumerable small chunks and there will be a ring around Mars as dark as those around the planet Uranus. Since the time scales for the demise of Triton and Phobos are comparable, it is interesting to speculate whether Neptune or Mars will win the race to be the next ringed planet of our solar system.

The future fate of Triton and Phobos may have already been experienced by other satellites in the past. For instance, is it possible that Venus may have once had a temporary ring system? A number of theories have been advanced to explain why two planets as similar as Venus and Earth are not both accompanied by moons. One view is that the earth is anomalous, having quite accidentally captured a very large stray object long ago. Another speculation, credited to coauthor Joseph Burns, is that Venus originally had a moon, but its lifetime was limited since the planet's slow spin causes satellites to be dragged into the planet by tides, as in the cases of Triton and Phobos. In other words, even if Venus started out with a satellite like our moon, the object would have crashed into the planet long ago or broken up on its way into the planet, giving rise to a temporary ring system around Venus. Since this satellite should have consisted entirely of rocky material, one must then explain the disappearance of this hypothetical ring debris. Sputtering, especially that due to micrometeoroid erosion, might be invoked, but radiation pressure and the Poynting-Robertson drag would be more effective. Some support for the loss of satellites in this way comes from the fact that Mercury, which is not currently seen to have a moon, is another slowly spinning planet.

As we have indicated, no matter how ring systems arise, they eventually erode away and much of the debris is lost to the parent body. Galileo may accordingly have only been premature in asking, "Has Saturn devoured his own children?" when in 1612 its rings seemed to disappear upon being seen edge-on.

Planetary scientists Joseph Veverka and Joseph A. Burns are associate professors at Cornell University.

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Wait. Do not throw away this magazine. That atrocious pun is not my fault. It was thrust upon me by a peculiar coincidence in the history of the common name of *Mytilus edulis*, that delicious mollusk in the blue-black, hinged double shell, which we call mussel because the Romans called it *musculus*. This is not just a hoary fact. *Musculus* literally means "little mouse" (*mus*). Evidently, the household rodent and the edible coastal shellfish struck the ancients as similar. They apparently felt the same way about mice and muscle since *musculus* is also the direct antecedent of "muscle" and had already taken on that meaning, at least metaphorically, in the sense of force or vigor, in classical times. In the flexing of the bicep, Romans saw an event that reminded them of the movement of a mouse. Fanciful, yes, but there is no arguing with primitive perceptions. The Romans did undoubtedly think of mice when they first looked seriously at mussels and muscles. In English, we now make an orthographic distinction between the two, but modern Italian continues to reflect the ancient confusion. It uses the same word, *muscolo*, for thews and for mussels.


John Steel/Animals Animals

From the gastronomic (not to mention the physiological) point of view, there is no real confusion here at all. When we eat mussels, we are eating muscles (as well as other tissue). Adductor muscles hold the two shells of the mussel tightly together. The cook's job is to make those muscles relax so that he or she can get at the little "mouse" inside.

This is not a difficult task, once you recall yourself to zoological reality and expunge from your mind the notion that there is any connection between mussels and mice. Even the ancients knew that. Moreover, they understood that the mussel is a fabulously delicious shellfish, much simpler and safer to deal with than clams and oysters because it is rarely eaten raw. And you do not risk cutting off your fingers with a knife while prying open tight-clenched living mussels. Cooking makes them open and has a partially sterilizing effect.

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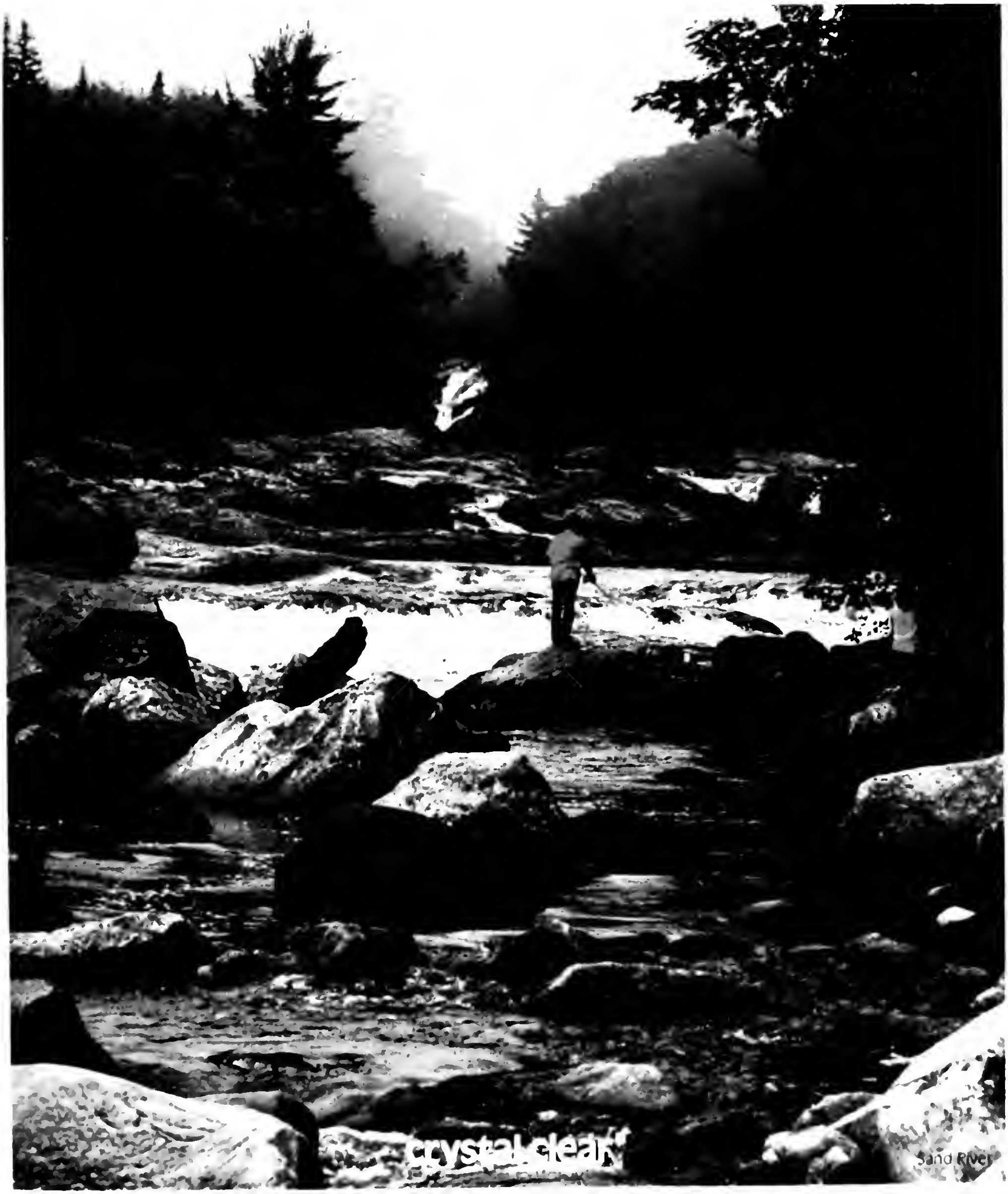

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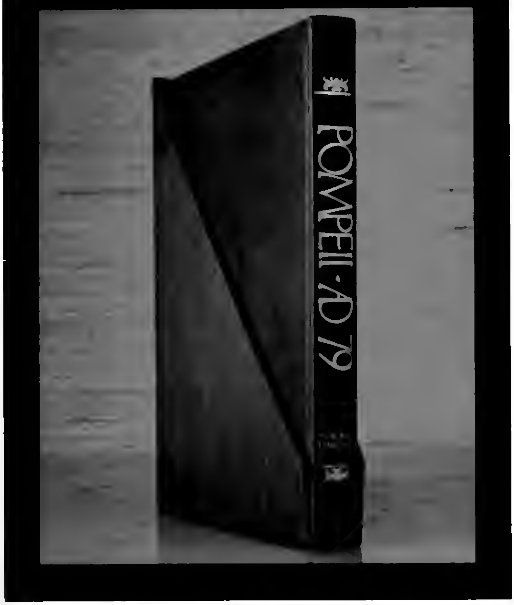

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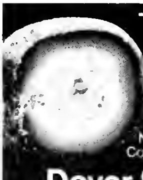

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mussel shoals flourish from relative inattention. During World War II, it is true, the Gulf of Maine was actively dredged and raked and tonged by commercial mussel fishermen. There was a worldwide scarcity of protein, and mussels, with 65.3 grams of protein per pound of shelled meat (hamburger averages 81.2 grams per pound) was an excellent alternative source. But even those wartime mussels were canned and shipped to countries where people love mussels.

Americans still turn up their noses at *M. edulis*. This is nutritional and ecological foolishness. Compared with other shellfish, mussels are a superior protein source and cost less because they are so abundant. Moreover, they do not compete with higher animals for food since they consume only plankton, which they filter from seawater.

But they are dirty. They come to us encrusted with mud and have a hairy beard (byssus), which extends in a scraggly tress from an opening between their shells. Inside, they are sandy, and they often produce small pearls of no value that make people fear for their teeth.

These are not insuperable problems. A healthy person armed with a stiff wire brush or a copper scouring pad can clean mussels with about the same speed that he can shuck corn. Pulling off the beards is a satisfying maneuver suitable for the entertainment of small children, who can be inveigled into doing it themselves. Soaking requires only the knowledge that it is necessary—and a basin of water. Pearls are a trivial and infrequent hazard. The odd thing is that all these drawbacks would be virtually eliminated if more Americans ate mussels. The wild beds would be depleted, and it would become profitable to farm "clean" mussels through systematic aquaculture.

This is easy to do and is common practice in northern waters all over the world. In May and June, the time of their natural spawn, mussel larvae attach themselves to any suitable substrate. Collecting infant mussels, or spat, on ropes or rafts or stakes is cheap and uncomplicated. In Spain, in deep bays not unlike those of the Maine coast, 5,500 square feet of raft surface yields 5,060 tons of mussels. An acre of seawater will produce 108,000 pounds of mussels a year or 20,000 pounds of high-grade protein. When they are allowed to develop in a three-dimensional space, suspended from the sea bottom, mussels grow larger and faster. Aquaculture maximizes their access to food in the water and protects them from bottom-dwelling predators, such as snails, starfish, and crabs. Aquacultured mussels are also cleaner. Their beards are smaller and can be removed more easily, with less trauma to the byssal gap, so that less of their delicious liquor escapes. Aquacultured mussels do not get clogged with mud, and they do not appear to grow pearls. Somehow, aquaculture prevents mussels from acquiring the small parasites called *Gymnophallus* whose presence provokes the growth of pearls.

With so many things to recommend it, mussel aquaculture caught on in Europe long ago. It dates to the thirteenth century, when an Irishman named Walton noticed that mussels attached to stakes set into the bottom of the ocean at the low-tide mark grew bigger and sweeter. Today, in France, these stakes, or *bouchots*, are a major source of mussels. In the United States, however, mussel aquaculture is still a new wrinkle. Americans need to develop an appetite for these bivalves before mussel farming can turn into big business. Meanwhile, they lie there by our shores, ready for casual harvest.

At Montauk Point, toward the end of last summer, I was walking on the sand, clambering over rocks, collecting pebbles, and watching the surf fishermen casting fecklessly for fish that wouldn't bite, when the steely glint of mussels caught my eye. Collecting several dozen in our pockets and shirts, my companion and I brought them home, cleaned them, and then grilled them over a wood fire until their shells opened. The wood imparted its flavor to the mussel meat, which remained juicy and, of course, absolutely fresh.

My second favorite recipe for mussels involves slightly more effort. *Moules marinière* is a classic fisherman's preparation that involves steaming mussels in a big pot over a small amount of white wine containing onions, butter, and seasonings. For two quarts of mussels, you need a cup of wine. The mussels open after five or ten minutes. The cooking liquid makes a fine sauce all by itself. Done this way, the mussels and liquid can be served together from the cooking pot. Or, more elegantly, you can shell the mussels and thicken the sauce with cream and/or egg yolks. The mussels can be served separately, hot or cold. And the thickened, creamed liquid makes a fine soup that can be further

refined with saffron or curry powder.

Some people make a mock-snail dish with mussels, stuffing the mussels in snail shells and covering them with the garlic butter used with snails.

Mussels can be skewered with bacon and broiled. They fry beautifully when breaded or when coated with yeast or beer batters. Italians open them raw, discard one shell, and sprinkle them with grated cheese, parsley, minced garlic, and a little olive oil before running them under the broiler.

Mussels lend themselves beautifully to fish soups. A bouillabaisse parisienne is a bouillabaisse with mussels in it. Mussels go well on pizzas. And they make a brilliant addition to pasta. Prepare the mussels as for *moules marinière* and keep them hot. Use some of the mussel cooking liquid in the pasta cooking liquid, and add the rest of the mussels to the finished drained pasta.

Not all mussel cookery is so simple and unpretentious. I recently ate a very sophisticated mussel soup with saffron at an elegant restaurant, and it was the best dish of the evening. Among the really arduous mussel recipes is the old-fashioned French method of stuffing raw mussels. You pry them half open, spoon in the stuffing mixture, then tie each one up with string and cook them in wine or tomato sauce.

Haute cuisine coats mussels with various sauces and compound butters. But the most interesting mussel ideas I know come from the great French cookbook of Ali Bab (see below) and from the seaside Italian town of Versilia, where they lightly sauté mussels in the half shell (turned over, so that the shells are on top) in a sauce of oil, vinegar, parsley, and cognac for five minutes, then pour in beaten, seasoned eggs, which are then cooked as for a *frittata* ("omelet"). Some egg has to be pushed under each mussel. When it is cooked, and if the cook has been careful to arrange the mussels in a single layer, the *frittata* presents a beautiful contrast of black and yellow.

Mussel dishes of all kinds are appearing more frequently on menus and should help to promote a general interest in *Mytilus edulis*. Logic, necessity, and good taste all point in the same direction, toward a national craze for mussels. But if it occurs, history will merely be repeating itself. Shell middens found at Catalina Island, California, show that aboriginal Americans first ate up all the available abalone, then turned to mussels. That fact ought to remove the last barrier to mussel acceptance—xenophobia. These mollusks are not a foreign notion; they are primordial native food, as American as Yankee Doodle's macaroni.

Ali Bab's Suçarelle de Moules
(Adapted from Ali Bab's *Encyclopedia of Practical Gastronomy*)

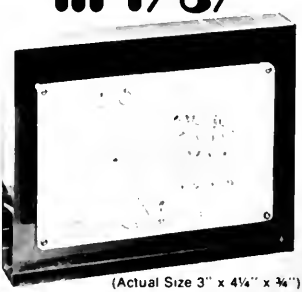
- 4 anchovies
- 7 tablespoons butter
- 3 quarts mussels
- 1 medium clove garlic, minced
- 1 medium onion, finely chopped
- 7 tablespoons tomato purée
- 1½ cups dry, sifted bread crumbs soaked in milk, drained, and pressed dry
- Salt
- Pepper
- Paprika
- 7 tablespoons heavy cream
- 2 egg yolks

1. Pound the anchovies with 3½ tablespoons of the butter and force through a sieve. Reserve.
2. Scrub the mussel shells with a wire brush or copper scouring pad. Debeard them. Soak them in salted water for 15 minutes. Discard any mussels that are notably heavy or that can be easily opened.
3. Put the mussels in a saucepan with ¾ of the garlic and toss them over high heat until they open. Remove them from their shells, but set aside a few in their half shells.
4. Over high heat, slightly reduce the mussel juices left in the pan. Strain, let sediment settle, and then decant the clear liquid. Reserve.
5. In 2 tablespoons butter, sauté onion and remaining garlic until onion turns translucent. Stir in anchovy butter, tomato purée, bread crumbs, salt, pepper, and paprika. Now add enough mussel water to make a fairly thin sauce. Simmer for 15 to 20 minutes.
6. Just before serving, thicken the sauce with the cream and the egg yolk. Whisk together and heat until the egg yolk thickens, stirring constantly. Do not boil.
7. Add the mussels and the rest of the butter. Heat up for an instant and serve on a dish garnished with the mussels on the half shell.

Yield: four servings.

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

in 1987



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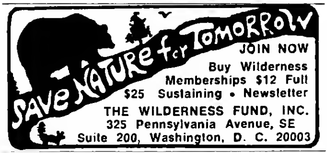

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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun is among the stars of Pisces in early April, moving eastward and northward each day; it crosses into Aries on the 19th. Its path across the sky at this time of year lengthens, moves higher at a noticeable rate, and causes the rapid increase of daylight. This is the season when we begin to observe that sunshine enters our northerly facing windows in the early morning and late evening.

In April and again in May, the moon is an evening object at the beginning of the month, quickly reaching first-quarter, and continuing to brighten the early evening hours until full moon. Before midmonth, however, the moon will rise at night, and early evening hours will be dark, until very late in the month when the evening crescent moon returns. Phases in April are: first-quarter on the 4th, full on the 12th, last-quarter on the 19th, new on the 26th. Phases in May occur in the same order but one day earlier. Apogee moon (farthest from the earth) is on April 6 and May 4; perigee (nearest the earth) on April 22 and May 18.

Stars and Planets Jupiter and Saturn are shown on the evening Star Map this month. The other visible planets, Mercury, Venus, and Mars, are morning objects, but are too close to the sun's direction to be easily seen. You will find Jupiter well up in the south at dusk, setting about midnight. Except for the moon, it is the brightest object in the evening sky. Saturn is in the southeast after sunset and sets in the west before dawn. It is near the bright star Regulus in Leo, to the east (left) of the star and a bit brighter. Mercury and Mars are in the constellation Pisces this month, Venus moves from Aquarius into Pisces, Jupiter is in Cancer, Saturn in Leo, Uranus in Libra, Neptune in Ophiuchus, and Pluto in Virgo. Uranus and Neptune are evening stars all month; Pluto becomes a morning star on the 8th.

April 1: The moon is near Aldebaran, in Taurus, tonight. Earlier, the moon covered the star (an occultation) over parts of Europe, Africa, and Asia. Mercury and Mars are in conjunction.

April 4–5: The bright object near the moon these nights is Jupiter, in Cancer. Mercury ends its retrograde motion on the 5th.

April 7–9: The moon passes Regulus and Saturn on the 8th. It is closer to Regulus on the night of the 7th, to Saturn on the 8th and 9th.

April 21: Mercury is at greatest westerly elongation (to the right of the sun), but rises late and quickly disappears into twilight.

April 22: The Lyrid meteor shower reaches maximum.

April 23–24: The moon occults Venus late on the 23rd and Mercury between 6:00 and 7:00 A.M., EST, on the 24th. Venus can be seen just to the moon's right after dawn on the 23rd. The occultation of Mercury will be visible from most of North America (except the western part) low and in the early morning sky.

April 28: The second occultation of Aldebaran this month occurs tonight between 8:00 and 10:00 P.M. (depending on location). This one is generally visible over North America during the early evening.

May 2: Jupiter is the bright object near the moon.

May 5: Mercury and Mars are again in conjunction. The Eta Aquarid shower (up to 20 per hour, but fast and sometimes bright) reaches maximum. Saturn is the bright object near the moon.

May 9: Saturn ends its retrograde (westerly) motion. The planet will separate to the east (left) from Regulus.

★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:20 P.M. on April 1; 10:25 P.M. on April 15; 9:25 P.M. on April 30; and 8:25 P.M. on May 15; but it can also be used for an hour before and after those times.


N
CASSIOPEIA
CEPHEUS
PERSEUS
CAMELOPARDALIS
Capella
AURIGA
April 2
LITTLE DIPPER
Polaris
DRACO
BIG DIPPER
URSA MAJOR
Castor
GEMINI
Pollux
April 4
April 30
Betelgeuse
ORION
W
BOOTES
Arcturus
Jupiter
May 3
Procyon
LEO
Denebola
Regulus
Saturn
April 8
VIRGO
May 7
HYDRA
Alphard
April 12
Spica
CRATER
CORVUS
S

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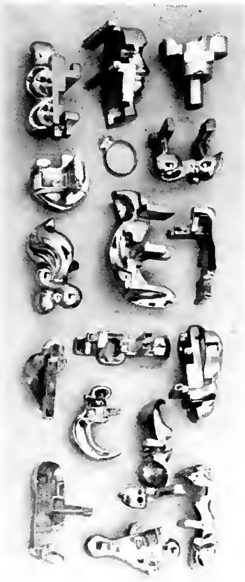

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Additional Reading

Bullfrogs (p. 30).

For a general reference on frogs, see the *Handbook of Frogs and Toads of the United States and Canada*, 3rd ed., by Albert H. Wright and Anna A. Wright (Ithaca: Comstock Publishing Co., 1949). Stephen T. Emlen and Lewis W. Oring attempt to explain and predict forms of animal-mating systems in "Ecology, Sexual Selection, and the Evolution of Mating Systems" (*Science*, July 15, 1977, pp. 215–23). One of the best early works on bullfrogs is "Territoriality in the Bullfrog, *Rana catesbeiana*," by S. T. Emlen (*Copeia*, June 5, 1968, pp. 240–43). "The Social Behavior of Anuran Amphibians," by K. D. Wells (*Animal Behavior*, vol. 25, 1977, pp. 666–93), is a general review. Additional information can be found in R. D. Howard's "The Evolution of Mating Strategies in Bullfrogs, *Rana catesbeiana*" (*Evolution*, vol. 32, 1978, pp. 850–71).

Pompeii Supplement (pp. 37–82)

Volcanoes of the Earth, rev. ed., by Fred M. Bullard (Austin: University of Texas Press, 1976), is an extensive summary of our present knowledge of volcanoes. Added features are the many illustrations, including color plates, and a 17-page bibliography. An authoritative discussion of volcanic products and phenomena can be found in Gordon A. Macdonald's *Volcanoes* (Englewood Cliffs: Prentice-Hall, 1972). A paperback by Peter Francis is also entitled *Volcanoes* (New York: Penguin Books, 1976). The influence

of another ancient volcano is the subject of "The Big Blast at Santorini," by Stephen Sparks and Haraldur Sigurdsson, which appeared in the April 1978 issue of *Natural History* (pp. 70–77). An introduction to systematic geomorphology, Cliff Ollier's *Volcanoes* (Cambridge: M.I.T. Press, 1974) treats volcanoes as landforms. Another book with a similar approach, first published in 1944, is C. A. Cotton's *Volcanoes as Landscape Forms* (New York: Hafner Press, 1969). *Volcanic Land Forms and Surface Features: A Photographic Atlas and Glossary*, was edited by Jack Green and N. M. Short (New York: Springer-Verlag New York, 1971). This annotated collection of large black-and-white illustrations, arranged by subject, also has a 66-page glossary.

A large, handsome book found in many art libraries is *Pompeii and Herculaneum: The Living Cities of the Dead*, by Theodor Kraus (New York: Harry Abrams, 1976). *Pompeii and Herculaneum: The Glory and the Grief*, by Marcel Brion (London: Paul Elek, 1977), while less lavishly illustrated, still has good photographic coverage. Michael Grant's *Cities of Vesuvius: Pompeii and Herculaneum* (New York: Penguin Books, 1978) is a black-and-white illustrated paperback that covers the daily life, temples, houses, and occupations in these two ancient cities.

Life and Leisure in Ancient Rome, by John P. V. D. Balsdon (New York: McGraw Hill Book Co., 1969), uses

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both ancient writings and archeological studies to describe all aspects of ancient life, including inns. H. H. Tanzer devotes a chapter of her book *The Common People of Pompeii* (Baltimore: Johns Hopkins Press, 1939) to inns. An art book that might be found in some libraries is *Pompeii, Its Life and Art*, by A. Mau (Washington: Consortium Press, 1971). *Pompeii AD 79*, by John Ward-Perkins and Amanda Claridge (New York: Alfred A. Knopf, 1978), the catalog of the Pompeii exhibition, which will open at the American Museum of Natural History on April 22, 1979, was published in association with the Museum of Fine Arts, Boston, and comes in two paperback volumes. In addition to describing the objects in the exhibition, it includes photographs of some of the excavations and background information on the history, art, and architecture of Pompeii.

Eleonora's Falcon (p. 85)

A recent treatment of raptor ecology can be found in *Birds of Prey*, by Leslie Brown (New York: A and W Publishers, 1977). R. E. Moreau covers bird migration in the Mediterranean region in *The Palaearctic-African Bird Migration System* (New York: Academic Press, 1972). *Animals in Migration*, by Robert T. Orr (New York: Macmillan Publishing Co., 1970), is a more general book. The latest information on Europe's sociable falcons and their prey is contained in volume 2 of the *Handbook of the Birds of the Western Palearctic*, Stanley Cramp, chief editor (New York: Oxford University Press, to be published in 1979).

Katharine D'Agosta

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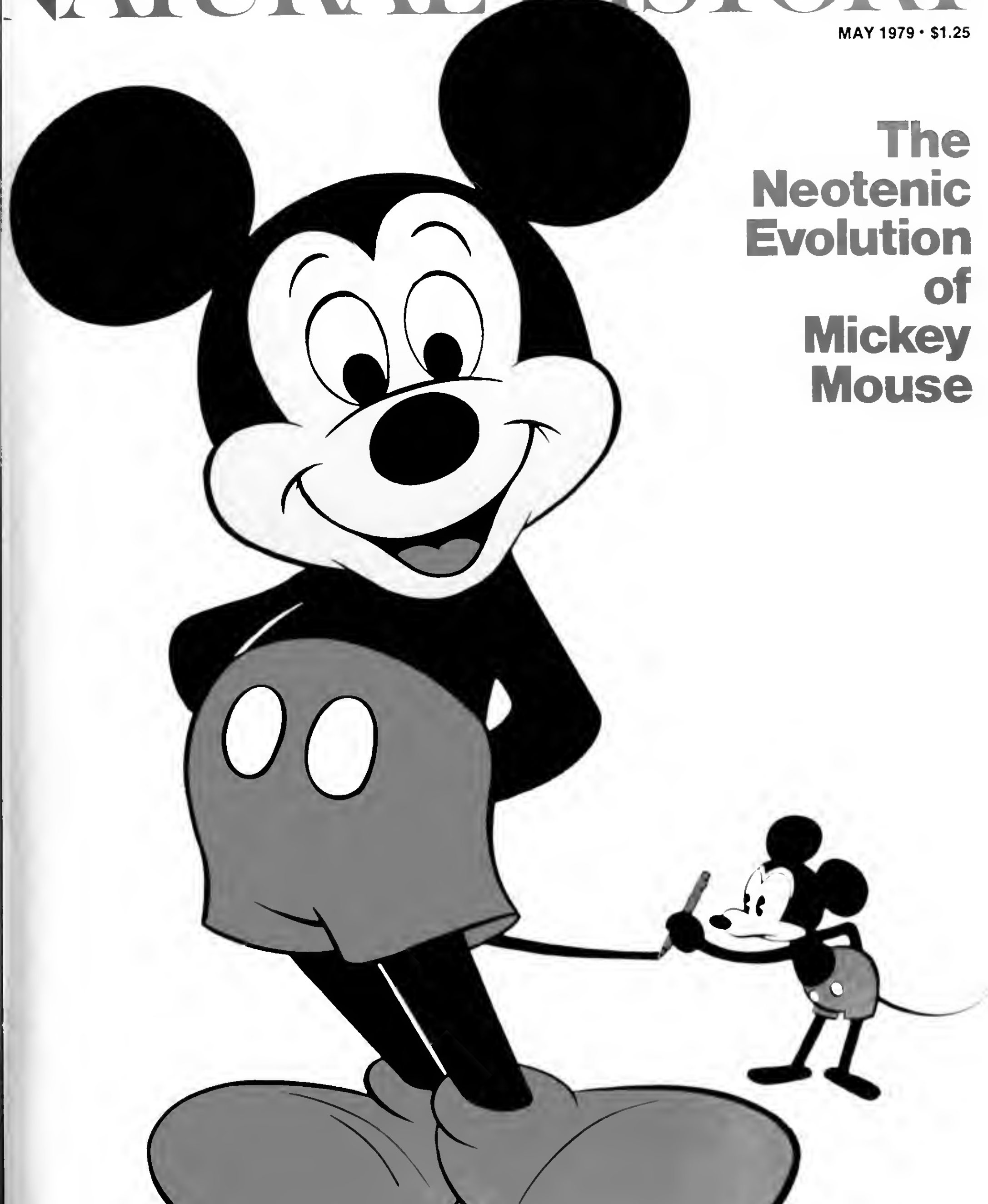

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"Aware of the masculine bias of our major museums, I resolved to strive for a greater visibility for women's participation in, and contributions to, American culture," says **Deborah Jean Warner.** Curator of the history of astronomy at the Smithsonian Institution's National Museum of History and Technology, Warner was in charge of the institution's recent exhibit, "Women in Science in Nineteenth Century America." She has written on the history of astronomy, astronomical apparatus, celestial cartography, and the role of women in science and technology. Warner, who has a master's degree in the history of science from Harvard University, lives in Maryland with her husband, four sons, and assorted pets, including two dogs, two cats, and a boa constrictor.

Chris Simon, a postdoctoral research associate in biology at the University of Chicago, is working out of the State University of New York at Stony Brook in pursuit of her evolutionary studies on periodical cicadas. This arrangement is not nearly as complicated as the relationships between the different forms of cicadas. Then there is the problem of *finding* her subjects. In May and June of 1976, Simon and an unwitting field assistant drove more than 10,000 miles tracking down brood XXIII of the thirteen-year cicada and traversing a good part of the Mississippi Valley in the quest. She will be off on a similar journey this spring as local populations of brood II of the seventeen-year cicada emerge all over the eastern seaboard. When not in pursuit of the wild cicada, she enjoys carpentry, quilting, and cooking ethnic dishes.

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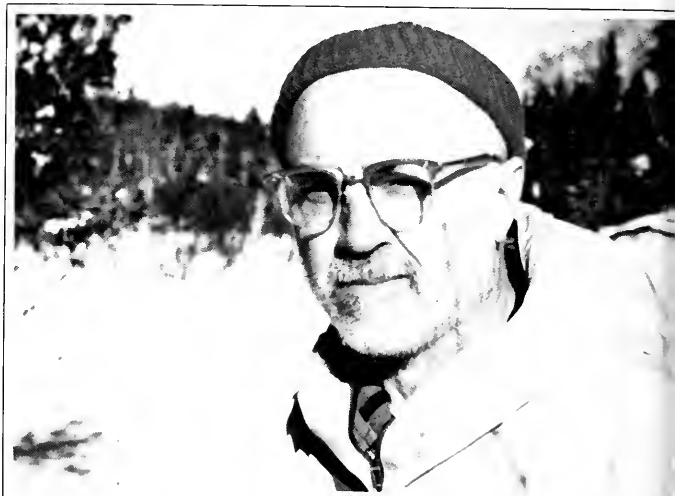

Isle Royale first came to the attention of **Durward L. Allen** in the 1930s when he was an undergraduate in zoology at the University of Michigan. The island's abundant moose population, protected from hunters, was suffering from overpopulation and food depletion. By the 1950s wolves had penetrated the area and Allen saw a perfect opportunity for the study of predator–prey relationships. His book *Wolves of Minong*, from which this month's article is excerpted, is an account of the eighteen years of research on Isle Royale wolves he conducted with students and colleagues. Allen is emeritus professor of wildlife ecology at Purdue University, Indiana.

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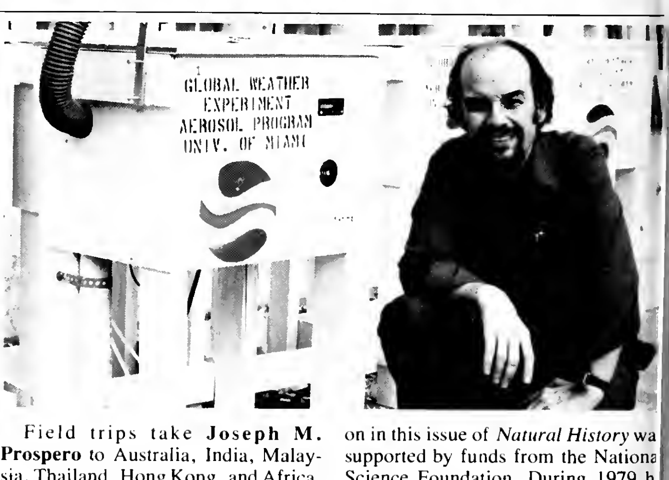

Field trips take **Joseph M. Prospero** to Australia, India, Malaysia, Thailand, Hong Kong, and Africa, where he studies the chemical and physical characteristics of marine aerosols, their distribution over the ocean, and their impact on meteorological and climatic conditions. Prospero is a professor in the division of marine geology and geophysics at the University of Miami's Rosenstiel School of Marine and Atmospheric Sciences. The research he conducted and reports on in this issue of *Natural History* wa[s] supported by funds from the Nationa[l] Science Foundation. During 1979 h[e] will again be out in the field, partici[-]pating in the Global Weather Experi[-]ment. "I will have aerosol samplin[g] gear and radiation measuring device[s] on twenty-one ships and eleven lan[d] stations distributed throughout th[e] tropics," he writes. "In June and Jul[y] I will fly aboard one of several aircra[ft] investigating the monsoon over th[e] Arabian Sea and the Bay of Bengal."

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Robert N. Campbell first saw the ravages of fire blight on trees in Minnesota, where he was a graduate student. Since his arrival in 1959 at the University of California at Davis, where he is now professor of plant pathology, he has seen blight on West Coast ornamentals and pears and has kept abreast of research on the disease for his class in introductory plant pathology. When not teaching or calculating how much longer gourmets will be able to enjoy *poire Belle Hélène* or *poire Williams*, Campbell investigates diseases of vegetable crops, especially those caused by fungi and viruses.

A professor of zoology at the University of Michigan, **Carl Gans** tries to maintain a mixture of laboratory and field research. The feeding, vocalization, locomotion, and defense mechanisms of reptiles have been of special concern to him. Before switching to biology, he worked for nine years as a mechanical engineer and has found the change from mechanisms of steam generation to those of animal locomotion a logical progression. His interest in uropeltid snakes dates back some thirty years, but it took twenty-one of them before he discovered his first specimen in southern India. Gans is currently in Australia, studying galloping crocodiles and burrowing lizards.

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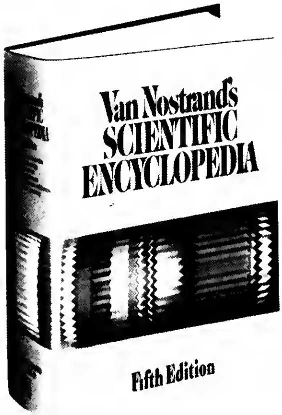

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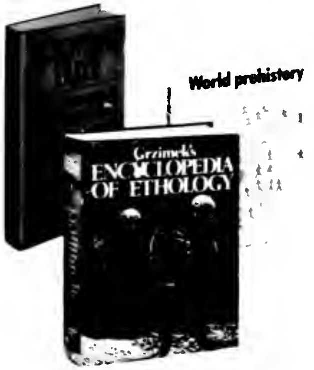

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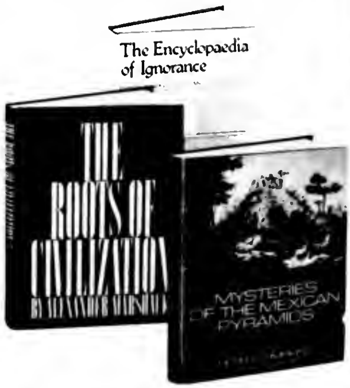

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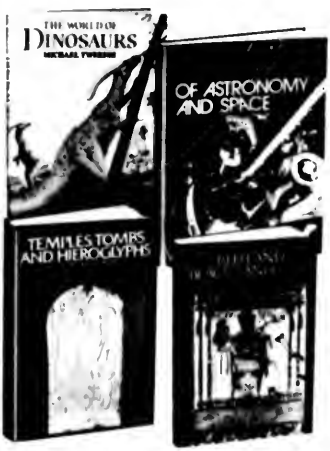

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Women Astronomers

Since about the mid-nineteenth century, women have slowly entered the scientific community in the United States, but they still have to contend with lingering bias

by Deborah Jean Warner

Throughout history one can find women known for their contributions to science, but never very many at any one time or place. Only since the nineteenth century, and particularly in the United States, have large numbers of women been able to study science and to involve themselves in its pursuit.

Public education for women, virtually nonexistent in the colonial and early republican periods, began to flourish in the 1820s. Within a few decades, dozens of female academies, seminaries, and colleges were established. The Packer Collegiate Institute in Brooklyn offered "all the advantages for thorough and complete education that are enjoyed by the other sex in our best appointed colleges," an aim shared by many.

The new schools for women, like those for men, placed a strong emphasis on science and boasted expensive science-teaching apparatus. At least six women's schools (many no longer in existence) had astronomical observatories before the Civil War. The one at Packer housed a six-inch equatorial refracting telescope made by Henry Fitz of New York, America's first successful commercial telescope maker.

The message was clear: although it did not yet offer many job opportunities, science was an important aspect of American intellectual culture and thus an appropriate subject for middle-class women to study.

Opened in 1865, Vassar was the first college for women with an endowment at all commensurate with that enjoyed by the leading colleges for men. Its observatory had a thirteen-inch equatorial refracting telescope (only slightly smaller than Harvard's fifteen-inch one) and a meridian circle for measuring the positions of celestial objects. But more important than any piece of apparatus was Vassar's professor of astronomy, Maria Mitchell. As Marie Curie would be for later generations, Maria Mitchell was a popular symbol of women's emergence from dependent domesticity into the public world of science.

All women scientists before the middle years of the nineteenth century relied on a male friend or relative for access to scientific apparatus and information. Mitchell was no exception. From her father, William, an amateur astronomer, she learned to calculate celestial positions and orbits, rate chronometers, and sweep the skies for unusual objects.

For most Americans of William Mitchell's generation, science was an avocation conducted with private resources, which was to be enjoyed for itself and brought no financial rewards. During Maria's lifetime (1818–88), the American scientific community developed from a handful of practitioners, largely isolated and independent, into a profession with established laboratories and museums, journals and libraries, schools and societies. For women, this professionalization proved a mixed blessing, opening opportunities in some areas while restricting them in others.

In the 1840s and 1850s, as librarian at the Nantucket Athenaeum, Maria Mitchell had access to advanced astronomical texts and the leisure to study them. Her discovery of a comet in 1847 catapulted her to fame, with a gold medal from the king of Denmark symbolizing her international recognition. The American scientific community honored her with membership in the newly established American Association for the Advancement of Science, and a part-time job computing the positions of Venus for the *Nautical Almanac*, a compendium for celestial navigation now published by the U.S. Naval Observatory.

After the Civil War, women began to take an increasingly active role in the world at large. At Vassar, Mitchell prepared her students for the rigors of the new graduate programs—specialized teaching in science had been initiated at Yale and Harvard in the 1840s, and other graduate programs followed in the postwar decades—and worked with the professional community to open advanced education and scientific jobs to women.

The path from the egalitarian sentiments of the eighteenth century to those of today's ERA took a wide detour in the nineteenth century. Even as women were moving into areas previously defined as for men only, and with no obvious damage to themselves or the areas, the differences between men and women were magnified as never before. According to the Cult of True Womanhood, women were pure, pious, dependent, and domestic. Even feminists seeking to enlarge the boundaries of women's proper sphere adopted the psychosexual line, arguing that women's special sensibilities were reason enough for their participation in science and politics.

"Women are needed in scientific work for the very reason that a

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wrest important correlations from their data. Her discovery that long-period variable stars could be identified by peculiarities in their spectra enabled her to find and analyze an incredible 222 of these particularly interesting, but hitherto relatively rare, stars. Annie Jump Cannon established the basic sequence of stellar spectra; she also found some 300 long-period variables. Antonia Maury discovered spectroscopic binaries, double stars identified by a periodic doubling of their spectral lines. Her later discovery of two distinct categories of stars of the same spectral class stimulated Danish astronomer Ejnar Hertzsprung's analysis of red giants and white dwarfs. From her scrutiny of thousands of variable stars, Henrietta Leavitt discovered the period-luminosity law, which enabled astronomers to find the distances of star groups too far away for simple parallax measurements.

For most women, however, the preeminently striking characteristic of their work was its magnitude. Annie Jump Cannon classified the spectra of more than 350,000 stars. Ida Barney was responsible for most of the reduction work for the thirteen-volume Yale Photographic Zone Catalogue of star positions, which required a half million measurements and twenty-three years of computational work. Isabella Lange, chief of the largely female computational staff at the Dudley Observatory in Albany, New York, had similar responsibility for the San Luis Catalogue of 15,333 stars, the Albany Catalogue of 20,811 stars, and the five-volume General Catalogue of 33,342 stars. A Mrs. Crissman, employed for forty-one years at the Allegheny Observatory in Pittsburgh, held the record for stellar parallax determinations: she measured the star positions on some 15,000 photographic plates and found the distances from Earth of about 500 stars. Precision was another quality for which women were known. Ellen Barndollar, a research assistant at the University of California at Berkeley, who worked on minor planet perturbations, was cited for having performed all computations in duplicate.

Three of the first women at Harvard were daughters of former observatory directors, another was an astronomer's wife, and Fleming had been Pickering's housekeeper. Yet Mitchell's prize student, Mary Whitney, could not get a job. Having earned a master's degree from Vassar and studied advanced mathematics at Harvard, she was perhaps too well educated for the work available to women. Not until the early decades of the twentieth century did the women's colleges have much success placing their graduates in observatories.

Before astronomical education became restricted to the halls of academe, most astronomers acquired their observational and mathematical skills working in observatories and laboratories or surveying. By 1900 some twoscore American men had earned doctorates in astronomy from European universi-

Women were used in the early 1900s at Harvard College Observatory to analyze and classify photographs of the spectra, brightness, positions, and motions of the stars.

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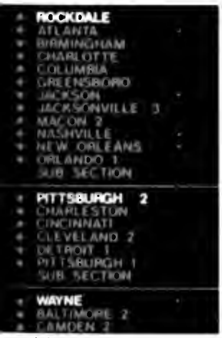

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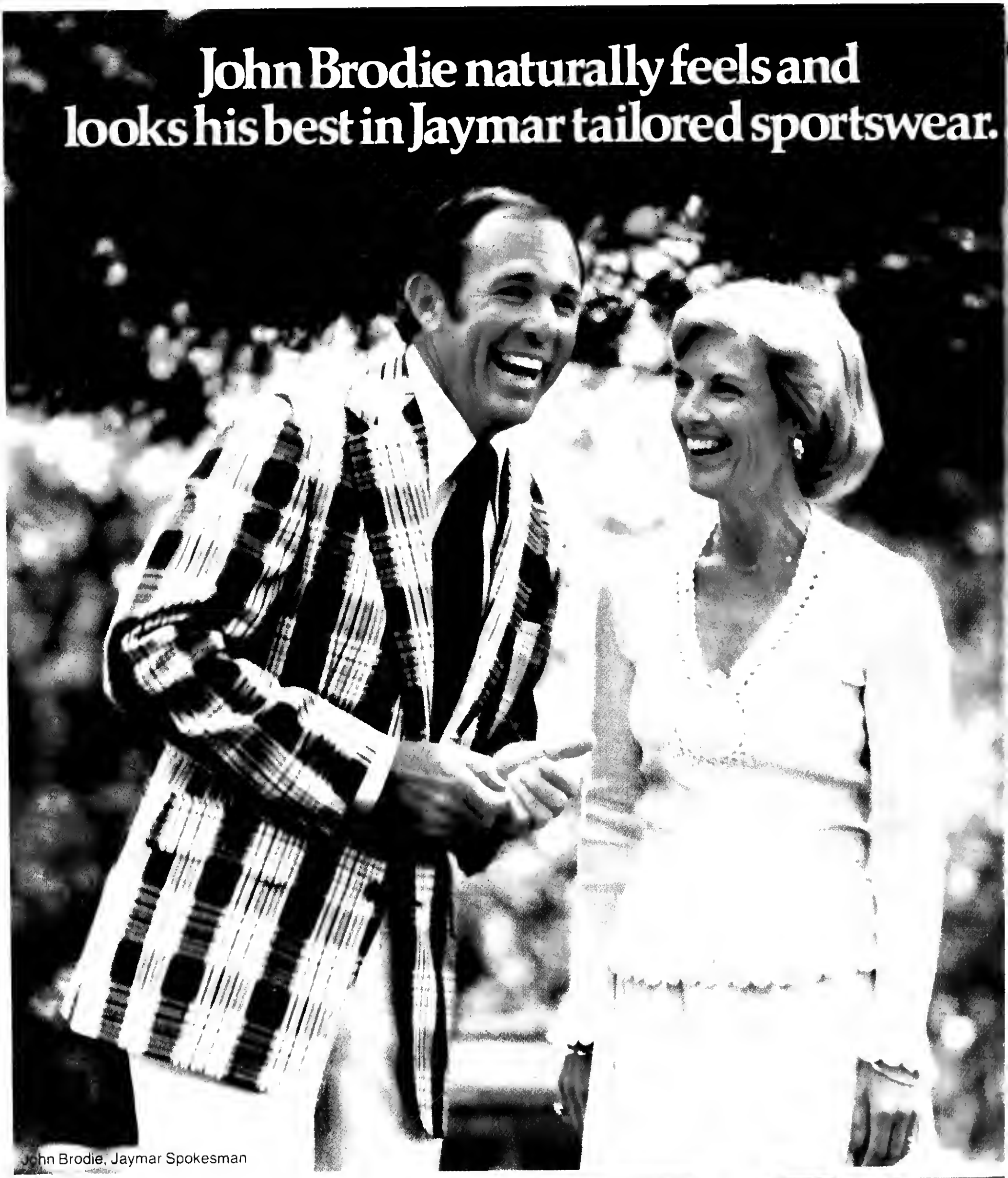

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Miami	Bentley Men s
Miami	Biscayne Merchandisers
Miami	Laepoca Dept Store
Miami	Lane s
Miami	Marino s Men s Shop
Miami	Monte Carlo Men s
Miami Beach	Mark 400
Miami Beach	Mr Ross Ltd
Miami Shores	Pauleen s
North Miami	The Place
Ocala	Malever s
Orlando	Walt Disney World
Plant City	Earl s Men s Wear
Pompano Beach	Richard James
Riviera Beach	Forest Men s Wear
St Petersburg	Bruno s Men s Wear
Sarasota	Carriage Clothiers
Sarasota	King James
South Miami	Lane s
Stuart	Forest Men s Wear
Sunrise	Car Fal
Sunrise	The Place
Surfside	Hamilton s Men s Wear
Tamarac	Car Fal

GEORGIA

Athens	Geo Gibson s
Augusta	Leon & Sons
Dawson	Maloof s
Doraville	The Gentleman s Shoppe
Fitzgerald	Halperin s
LaGrange	Mansour s
Lithonia	The Gentleman s Shoppe
Mableton	Ruff s Clo
Statesboro	The Sir Shop

HAWAII

Honolulu	Palm Beach Shop
Honolulu	Ross Sutherland

IDAHO

Coeur D Alene	Fisher s
Nampa	Nalziger s

ILLINOIS

All Stores — M Hyman & Son

Addison	Malina, Inc
Antioch	B-J s Fashion for Men
Arthur	Delbert s
Blue Island	Boyd s
Chicago	Brighton Clo
Chicago	Tom Hynes Inc
Chicago	Mexis
Chicago	Tony s
Chicago	Wieboldt Stores
Edwardsville	Imber s Menswear
Effingham	The El Matador
Forest Park	Krest Custom Tailors
Geneseo	The Raquet
Harrisburg	Gentlemen s Image
Hickory Hills	Lew Bass & Sons
Jacksonville	Mr Wes Menswear
Kankakee	Mister Marsh
LaGrange	David s
LaGrange Park	Jack s Men s Shops
Lacon	Dale Parsons Ltd
Marion	Village Squire
Monticello	Mr Kelly s
Oak Lawn	Mal s Men s Shop
Oak Lawn	Malina Inc
Orland Park	Bylon s
Palos Heights	Bud's
Palos Heights	Jac s Men's Wear
Peoria	Carson Pirie Scott
Rockford	John Carlson s
Rockford	Knight's Armour
Steger	Steger Clothing Co
Sycamore	Johnson s
Tinley Park	Jimmy s Men's Wear
W Frankfort	The Brad Shop
Waukegan	Storey's
Western Springs	For Men

INDIANA

Angola	Strocks
Bedford	The Toggery
Brazil	Gallery of Fashions
Carmel	Fogels
East Chicago	Lewin s
East Chicago	Mill s
Elkhart	Myers Men's Wear
Evansville	Mr Fashion
Greenwood	David Williams
Highland	Highland Dept Store
Highland	Lewin's
Hobart	Edward s
Indianapolis	Arnold's
Indianapolis	Fogels
Indianapolis	Hudson s
Indianapolis	Style Store
Lafayette	Dent s
Lowell	The Toggery
Marion	Milton s
Merrillville	Superior Tailors
Michigan City	Blake s
Michigan City	Todd-Grieger's
Mishawaka	Larry s Esquire Shop
Nappanee	J & R Coppes
New Albany	P A Niemeier
New Castle	Lloyd Beall
Whiting	The Garment Wheel

IOWA

Ankeny	Dave s Apparel
Bettendorf	Lord Cumberland
Cedar Rapids	Holley s
Council Bluffs	Iowa Clothes
Des Moines	Geva s Apparel
Des Moines	Mr B s
Manson	Foley Clothing
Muscatine	Fox s
Okoboji	Green s
Sioux City	Black Knight

KANSAS

Coffeyville	Weinberg s
Great Bend	Brentwood Ltd
Kansas City	Shepherd s
Liberal	Kelly s
Overland Park	Jerry Leonard
Topeka	Cunningham Shields
Wichita	Dillard s
Wichita	Jerry Leonard

KENTUCKY

Lexington	Dawahares
Louisville	Levy Bros
Murray	Corn Austin
Owensboro	The Coachman
Paducah	Trad Shop

LOUISIANA

Abbeville	Gary s
Alexandria	Caplan s
Baton Rouge	Cohn-Turner
Baton Rouge	Four Corners
Baton Rouge	Goudcheaux s
Bossier City	Pope s
Houma	Gentlemen s Corner
Houma	Earl Williams
Lafayette	Abdalla s
Lafayette	Gaidry s
Lafayette	Emile Joseph s
Lake Charles	Gaidry s
Monroe	Sol Snyder s
Monroe	The Toggery
Morgan City	Du Rai s
New Iberia	Broussard s
New Orleans	Gemelli s
New Orleans	Hesse s Sportswear
New Orleans	M Ponce Inc
New Orleans	Porter s-Stevens
Shreveport	Jordan & Booth
Thibodaux	Johnny's

MARYLAND

Lutherville	Andrew s
Pikesville	Max Margolis
Towson	Andrew s

MASSACHUSETTS

All Stores — Wallachs

Boston	Arlie s
Braintree	Natale s
Cambridge	Congress Men s Shop
Pittsfield	Berkshire Hills Shop
Stoughton	Martin Edwards Ltd
Worcester	Rawan Ltd

MICHIGAN

All Stores — Shifman's

Allegan	McGowan s Men s
Davison	Homer Hill
Dearborn	Towering Man
East Lansing	Hattner s Big & Tall
Fenton	The Fenton Haberdashery
Grand Rapids	Captain s Quarters
Grand Rapids	Jurgens & Holtvluwer
Grand Rapids	Wm Klein
Grand Rapids	Roger's Dept Store
Holland	Lokker-Rutgers
Kalamazoo	Jud Knapper
Lansing	Leonard s
Marshall	Miller-Aalbregtse
Monroe	Prince George
Muskegon	Vel s Clo
St Clair Shores	Wales Big & Tall
Ypsilanti	Hattner s

MINNESOTA

Brooklyn Ct	Jerry Leonard
Duluth	M & K
Hutchinson	Country Gentlemen
Minneapolis	Cedric's
Minneapolis	Jerry Leonard
Minneapolis	Liemandt s
Moorhead	Palace Clothiers
St Paul	Cedric s
St Paul	Jerry Leonard

MISSISSIPPI

Biloxi	Gayfer's
Columbus	Reed s
Flora	Stegall s
Jackson	Gayfer's
Laurel	Hamilton Graves
Louisville	Jones Men s Wear
McComb	Tailors Bench
Meridian	Marks Rothenberg
Meridian	Harry Mayer
Natchez	Benoist Bros
Ocean Springs	Stag Shoppe
Pascagoula	Brumfield s
Pascagoula	Stag Shoppe
Tupelo	Regs for Men
Vicksburg	Kerl s

MISSOURI

Cape Girardeau	Howard's
Chesterfield	Roy Alu
Independence	Jerry Leonard
Kansas City	Jerry Leonard
Lebanon	Clarks
St Louis	J B Simpson Clothes
Springfield	Dillard s
Springfield	Freeman s

MONTANA

Missoula	The Gentry

NEBRASKA

McCook	Vogue Clo
Omaha	Jerry Leonard

NEVADA

Las Vegas	Orodine
Las Vegas	Silverwoods
Reno	Dee s House of Big & Tall

NEW HAMPSHIRE

Manchester	Anthony s

NEW JERSEY

All Stores — Wallachs

Bordentown	Miller Megowan
Bridgeton	Rovner s
Hamilton Square	Bartholomew Louis
Moorestown	Traditional Men
Pottsville	Bohorad s
Trenton	Jack s Custom Shop
Vineland	Dom Michaels
Wildwood	Allen s

NEW MEXICO

Albuquerque	Jalen s Big & Tall
Albuquerque	Kistler-Collister

NEW YORK

All Stores — Wallachs

Buffalo	Kleinhans
Buffalo	Riverside Men s Shop
Elmira	Gentlemen s Quarters
Jamestown	Carnahan s
North Syracuse	Gary s
Rochester	Bauman Men's Wear Inc
Rochester	Mike Zelf Ltd
Rome	Simpkin s
Syracuse	Gary s
Troy	Kelly Clothes
Utica	A Vitullo

NORTH CAROLINA

All Stores — J D Jones

Asheville	The Man Store
Boone	Dougherty s
Burlington	Zibo s
Durham	Belk-Leggett
Elkin	Wagoners
Hickory	Belk-Broome
Hickory	Christopher s
High Point	Belk-Beck
High Point	Wright's
Jacksonville	Albert s
Lenoir	Lee & Robbins
Louisburg	Town & Country
Marion	The Gent Shop
Morganton	Burand s
Raleigh	Hudson-Belk
Rocky Mount	Rosenbloom-Levy
St Pauls	Joe Sugars
Southern Pines	Sir Richard Ltd
Statesville	Hine-Bagby
Wendell	Kennon s
West Jefferson	Jefferson House
Wilmington	Fleishman s
Winston-Salem	Hine-Bagby

NORTH DAKOTA

Bismarck	Shark s & Evan s
Dickinson	The Fad
Minot	Jay s Men's Store

OHIO

Akron	Bernie s
Bryan	Russell s
Canton	Mr Ted
Defiance	The Squire Shop
Hicksville	Scott s Men s Store
Mt Vernon	Worley s

OKLAHOMA

All Stores — Dillard's

Altus	Surrey Shop
Bartlesville	Dan s Men s & Boys
Chickasha	Hick s Crutcher
Claremore	Men s Shop
Oklahoma City	Mr Dales
Oklahoma City	Men s World
Purcell	Hick s Crutcher
Woodward	Ken s Haberdashery

OREGON

Albany	Phil Small
Coos Bay	Rosie s Place
Grants Pass	Griffith s
LaGrande	Trotter s
Salem	Bishop s

PENNSYLVANIA

Altoona	Fisher s
Clarion	Cmarada/Yukich
Dallastown	DeVono s
Dunmore	Philip Friedman
Erie	Isaac Baker & Son
Greenville	Waser s
Johnstown	Miller's
King of Prussia	Traditional Man
Lock Haven	Hoy s
Malvern	Englund's
McKeesport	David Isreal
Meadville	Weldon s
Philadelphia	Boyd s
Washington	The Hub
Wilkes Barre	John B Stetz

RHODE ISLAND

New Providence	Montecello s
Providence	Dino s

SOUTH CAROLINA

Greenville	McDonald s Men s
Hilton Head Island	The Red Jacket
North Augusta	Belk
Warwick	Wallachs
Sumter	Capitol Dept Store
Sumter	Gentleman s Corner

SOUTH DAKOTA

Aberdeen	Jorgensen s
Aberdeen	Plymouth Clo Co
Huron	Hedblom The Clothier
Mitchell	Small s Clo
Rapid City	Dilquist s
Sioux Falls	Norman s

TENNESSEE

Bristol	Quality Shop
Gatlinburg	Tomlinson s
Memphis	Stag Men s Shop
Memphis	Wilbanks & Everett
Nashville	Belmont Men s Shop
Paris	Corn Austin
Tullahoma	Clyde Phillips

TEXAS

All Stores — Dillard s

Abilene	Grissom s
Amarillo	Coat s Clothiers
Amarillo	Kevin Francis Clothiers
Arlington	Watson's
Austin	Cliff s
Austin	Merritt Schaefer & Brown
Beaumont	The White House
Brownsville	Europe Men s Fashions
Brownsville	LeBaron
Brownsville	Peri Bros
Bryan	Gentleman s Quarter
Carthage	M & M Toggery
Cleburne	Twaddell's
Corpus Christi	Winsteads
Corsicana	Morgan-Jones
Dallas	L D Hammons
Dallas	The Trophyman
Dallas	Jas K Wilson
Ft Worth	Cox's
Gainesville	Mr Britches
Houston	Dudley's Men s Wear
Houston	Leopold, Price & Rolle
Houston	Norton Ditto
Houston	Rodney's
Houston	Zindler's
Huntsville	Canon & Henry
Huntsville	The Collegiate Corner
Hurst	Watson's
Jacksonville	Ron Moore s
Kerrville	Wolfmueller's
Lamesa	Collin's
Lewisville	Tomlin Clothiers
Littlefield	Were s
Longview	Turpie Slade
Lubbock	S & O Clothiers
Lufkin	Blackstock's
McAllen	Baum s Men s Wear
McAllen	Christopher's
McAllen	Ken s
McAllen	LeBaron
McAllen	The Man s Shop
McAllen	Mike s Man Shop
McAllen	The Squire Shop
Mexia	The Stagg Shop
Nacogdoches	Jimmie Simms
Odessa	Jim s Tall & Big
Odessa	Melvin s Clothiers
Odessa	The Model Shop
Orange	Griffin s
Overton	Hodge s Men s Shop
Pampa	Brown-Freeman
Pharr	LeBaron
Rio Grande City	LeBaron
Rockwall	Wolfgang s Men's Wear
San Angelo	Mr Sam's
San Angelo	Tindall's
San Antonio	Duffy T's
San Antonio	Frank Bros
San Antonio	Satel's
Sherman	Gentry
Spring	The Men's Shop
Uvalde	Rowlands
Wichita Falls	Muehlberger s

UTAH

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Logan	Levens
Salt Lake City	Utah Woolen Mills

VIRGINIA

Arlington	Crystal Plaza Clothiers
Lebanon	Lebanon Dept Store
McLean	Allyn s Men s shop
Middleburg	The Country Gentleman
Richmond	Lee-Jay s
Suffolk	G S Hobbs Clothiers

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Ephrata	Geesey s
Mt Vernon	Cliff Johnson s
Seattle	Continental Tailoring
Seattle	Frederick & Nelson
Seattle	Klopfensteins
Tacoma	Oslund s Men s Room
Walla Walla	Sporleders

WEST VIRGINIA

Beckley	Lilly s
Clarksburg	Melet s
Huntington	Lambros
Princeton	The Stag
Williamson	The Man s Shop

WISCONSIN

All Stores — The Hub

Janesville	Murl's
Milwaukee	Gieringer s
Milwaukee	M Hyman & Son
Oconto Falls	H Bauman
Watertown	Kern s
Waukesha	J Laing & Son
West Bend	Sager s

PUERTO RICO

Humacao	Raymond Men s Store
Ponce	B Domenech & Sons
Rio Piedras	Casa Cuesta
San Juan	Continental Men s Wear
San Juan	Frank s
San Juan	Gentleman
San Juan	Carlos Martinez
San Juan	Gonzalez Padin
San Juan	Ultra Dept Store

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MAR

ties, and a like number from American ones. But by and large they were not the leaders in the field.

Excluded from on-the-job training—except within the very restricted areas defined as women's work—women were more dependent on formal university programs. Entrance to these came slowly. In the 1870s a few institutions allowed a few women to attend classes as special students. These women paid no tuition, received no degrees, and set no precedent.

An 1883 Wellesley graduate, Winnifred Edgerton, applied to Columbia University for advanced training in astronomy and was refused. After petitioning the tradition-bound trustees she gained admission, with the proviso that she "established no precedent for others." Two years later, in 1886, she became the first American woman to earn a doctorate in astronomy—and also the first woman to earn a Columbia degree. Her experience was to be repeated time and again by women at different institutions and in different fields. The doors to graduate education opened but only with persistent effort.

Four American women astronomers earned doctorates in the 1890s, three in the first decade of the twentieth century, and seven in the second. The rate then rose to about sixteen doctorates per decade and remained at that level from the 1920s through the 1950s.

A doctorate in astronomy, whatever private satisfactions it represented, was no guarantee of a research job. Dorothea Klumpke, an American who received a Ph.D. from the Sorbonne in 1893, was hired to direct the female computational staff at the Paris Observatory, and Margaretta Palmer, who earned a Yale Ph.D. in 1894, remained on the computational staff there. But they were the exceptions.

Most of the women with doctorates worked in the eastern women's colleges, notably Vassar, Smith, Wellesley, and Mount Holyoke, and the coeducational Swarthmore. Between 1865 and 1926 sixteen women served as professors and sometimes directors of observatories in these schools. Eight of them held earned doctorates, four held honorary ones, and two held master's degrees. Many were described as inspiring teachers. All were active members of various professional scientific associations. Although all were interested in research, their time, for the most part, was devoted to their students.

By the 1920s the position of women in astronomy appeared assured. Annie Jump Cannon was heaped with honors, including honorary fellowship in the Royal Astronomical Society and the Henry Draper Medal for Astrophysics from the National Academy of Sciences. In 1925, the same year that Cannon became the first woman to receive an honorary doctorate from Oxford, an Englishwoman, Cecilia Payne, became the first person to earn a Harvard doctorate in astronomy. According to astrophysicist Otto Struve's chronicle of modern astronomy, her dissertation was "undoubtedly the most brilliant Ph.D. thesis ever written in astronomy." Published as *Stellar Atmospheres* (1925), it was the first book to issue from the Harvard College Observatory. Equally important, a few women with doctorates—notably Cecilia Payne at Harvard, Hazel Marie Losh at the University of Michigan, and Helen Sawyer Hogg at Toronto—were able to get research positions.

Pioneer historians of the women's movement who concentrated on the political arena have noticed that a disenchantment set in soon after national suffrage was won. The enthusiasm that had carried women to victory in 1920 palled with the realization that access to the vote did not lead immediately or inevitably to full and equal participation in society. A similar withdrawal, or disenchantment with earlier concerns, has been noted in the lives of academic women in general from the 1920s through the 1950s, and I see it in the case of female astronomers.

This disenchantment became most evident in the prime feminine mystique years of the late 1940s and 1950s. Women's membership in the American Astronomical Society, which amounted to 10 percent in 1900, peaked at about 17 percent in the late 1930s and then fell sharply. The fifteen women who earned astronomical Ph.D.'s in the 1920s represented better than 25 percent of those doctorates earned during that decade. There was a slight decrease in the 1930s, probably for economic reasons. In the 1940s the number jumped to twenty-two and owing no doubt in part to men's military involvement, these twenty-two women represented about 25 percent of the earned doctorates at that time. In the 1950s the number of women studying astronomy decreased, while the number of men rose dramatically. The percentage of doctorates granted to women fell to about 10 percent and has remained at that level to this day.

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The twenty-two women who earned doctorates in the 1940s were, on the whole, less distinguished than similar groups at other times. Only 59 percent were listed in *American Men of Science*, compared with 82 percent of the women who earned Ph.D.'s in the 1930s, and 88 percent in the 1950s. Some of these women were able to use their professional educations to good advantage, but the majority did not find work opportunities commensurate with their training.

A major factor behind the disenchantment was the division of labor that had locked women into dead-end jobs. Tasks that had challenged the pioneers presented little satisfaction to succeeding generations of well-trained professionals. To quote H.H. Turner, professor of astronomy at Oxford, "Doubtless the work is done best by those who have had the experience, but to spend a whole life in such computing has manifest disadvantages, both for the individual and for the institution which must pay him an increasing salary with little corresponding return." Turner's solution was to hire music students on a temporary basis. Pickering at Harvard, even as early as 1898, had noted that mass-production data processing did not offer much opportunity for individual advancement.

A half century later Otto Struve remarked that "participation in a large routine program, developed and supervised by the director, had little to attract a brilliant young man," and that it was widely recognized that such projects had "done much harm by virtually killing the ambitions of hundreds of the younger astronomers in Europe." As Struve noted, this routine work was done by men as well as women, but women were ordinarily restricted to it while men were not.

Despite the occasional token woman who succeeded in breaking into other and more independent aspects of astronomy, by and large the observatories kept women in their place. At Mount Wilson, for example, all the women on the staff worked in the computing division in the office in Pasadena rather than as investigators. The residence for observers on the mountain was named "The Monastery" and was built with toilet facilities for men only.

Another factor affecting women's participation in professional astronomy has been the changing attitudes toward marriage. Of the sixty-three American women astronomers born before 1900 whom I have been able to identify, only fourteen married, less than one in four. Of the eleven female charter members of the American Astronomical Society only Williamina Fleming had ever been married, and she was a divorcée. Of the sixteen female astronomy professors previously mentioned, all were spinsters; the two who did marry resigned their jobs immediately. Wifehood and motherhood were deemed career enough. Married women generally sought paid employment only from necessity. Unmarried male astronomers, by contrast, were the exception rather than the rule.

In the twentieth century—as Freudian notions linking anatomy and destiny, and deprecating all sexual and emotional relations but monogamous, heterosexual ones, gained widespread currency and as extended families disintegrated—spinsterhood lost much of the social and psychic acceptability it had previously enjoyed. Several women with promising graduate and early professional careers married, quit their tenure-track jobs, and lost their places in the professional hierarchy. Like so many women described by sociologist Jessie Bernard in her book *Academic Women,* they placed themselves in fringe benefit status: assisting their professional husbands, teaching in junior colleges, holding various part-time and research associate positions.

Family–career role conflict remained intense for at least forty years, from the 1920s through the 1950s. Even the late Margaret Mead and her associate Rhoda Metraux, in a 1957 study of "The Image of the Scientist among High-School Students," presumed that male scientists would probably marry and female scientists would not. A few numbers will indicate the magnitude of the problem. Eight of the fifteen women astronomers who earned Ph.D.'s in the 1920s married. Of these, only two remained active professionals; four stopped work altogether after marriage; two went back to work briefly and only many years later.

Of the twenty-two women Ph.D.'s of the 1940s, nine dropped from astronomical sight completely, most because of marriage. Another five married nonastronomers whose work took them far from observatories or universities with graduate astronomy programs. Accepting jobs near their husbands' places of employment, these women worked in fields often only pe-

Newsweek, January 15, 1979

A VW FOR ANWAR

To set a belt-tightening example for his financially strapped country, Egyptian President Anwar Sadat has ordered a fleet of economy cars as replacements for gas-guzzling government limousines. Sadat himself, who used to ride in a Cadillac or a Mercedes-Benz, now tootles around Cairo in a chauffeured Volkswagen, and other Egyptian officials will soon be doing likewise. Sadat got the idea while watching a VW commercial on TV during a visit to the U.S.

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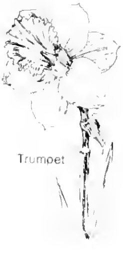
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ripherally related to their primary academic interests.

The assumption of strong psychosexual differences, which had facilitated women's entree to observatories, was to underlie almost all considerations of women scientists in the twentieth century. In his opening remarks at a 1964 M.I.T. symposium on "Women and the Scientific Profession," psychologist Bruno Bettleheim spoke of "a womanly embracing of her tasks rather than a masculine conquering of them."

The world of professional science was seen as masculinely oriented and as demanding a special kind of devotion to hard and lonely work that was essentially incompatible with a woman's primary allegiance to "her life as wife and mother." The fear was not only that a working woman would perforce neglect her family but that contamination by the world at large would destroy her purity and thus her ability to give her family the emotional and moral guidance it needed and deserved. A dozen years later, at a Harvard symposium on astronomy and space sciences entitled "Space for Women," discussion again centered on the assumed conflict between nurture and a professional commitment to science, a problem men seldom faced.

For working women in general, however, and for astronomers in particular, factual change preceded theoretical questioning. The percentage of women with astronomical doctorates who married remained the same in the 1950s as in the 1940s but, despite the feminine mystique, married women in the latter decade were able to continue their astronomical work. In 1973, owing in part to a growing recognition of the androgynous nature of both career and family activities, 70 percent of women astronomers were married.

In the past several decades, with greatly expanded support for science in general, the number of women astronomers has increased significantly. Thirty-seven women earned astronomical Ph.D.'s in the 1960s, twice as many as in the previous decade, and the high rate of increase continued in the early 1970s. At the same time, women have been able to gain access to research opportunities hitherto closed, and they have been granted some status and recognition for their achievements. In 1965, for example, Vera Rubin, now in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, became the

How to Profit from The Revenue Act of 1978

The Ultimate Tax Shelter

by
TED NICHOLAS

Tax experts are now referring to a small, privately owned corporation as "The Ultimate Tax Shelter." This is especially true with the passage of the Revenue Act of 1978. This law makes most former tax shelters either obsolete, or of little advantage. Investments affected include real estate, oil and gas drilling, cattle feeding, movies, etc. These former tax shelters have lost their attractiveness. Aside from that, these tax shelters required a large investment. Only a small segment of the population could benefit from them.

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There are still other advantages. Your own corporation enables you to more easily maintain continuity and facilitate transfer of ownership. Tax free fringe benefits can be arranged. You can set up your health and life insurance and other programs for you and your family wherein they are tax deductible. Another very important option available to you through incorporation is a medical reimbursement plan (MRP). Under an MRP, all medical, dental, pharmaceutical expenses for you and your family can become tax deductible to the corporation. An unincorporated person must exclude the first 3% of family's medical expenses from a personal tax return. For an individual earning $20,000 the first $600 are not deductible.

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A word of caution. Incorporating may not be for you right now. However, my book will help you decide whether or not a corporation is for you now or in the future. I review all the advantages and disadvantages in depth. This choice is yours after learning all the options. If you do decide to incorporate, it can be done by mail quickly and within 48 hours. You never have to leave the privacy of your home.

I'll also reveal to you some startling facts. Why lawyers often charge substantial fees for incorporating when often they prefer not to, and why two-thirds of the New York and American Stock Exchange companies incorporate in Delaware.

You may wonder how others have successfully used the book. Not only a small unincorporated business, but enjoyable hobbies, part time businesses, and even existing jobs have been set up as full fledged corporations. You don't have to have a big business going to benefit. In fact, not many people realize some very important facts. There are 30,000 new businesses formed in the U.S. each and every month. 98% of them are small businesses; often just one individual working from home.

To gain all the advantages of incorporating, it doesn't matter where you live, your age, race, or sex. All that counts is your ideas. If you are looking for some new ideas, I believe my book will stimulate you in that area. I do know many small businessmen, housewives, hobbyists, engineers, and lawyers who have acted on the suggestions in my book. A woman who was my former secretary is incorporated. She is now grossing over $30,000 working from her home by providing a secretarial service to me and other local businesses. She works her own hours and has all the corporate advantages.

I briefly mentioned that you can start with no capital whatsoever. I know it can be done, since I have formed 18 companies of my own, and I began each one of them with nothing. Beginning at age 22, I incorporated my first company which was a candy manufacturing concern. Without credit or experience, I raised $96,000. From that starting point grew a chain of 30 stores. I'm proud of the fact that at age 29 I was selected by a group of businessmen as one of the outstanding businessmen in the nation. As a result of this award, I received an invitation to personally meet with the President of the United States.

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first female guest investigator on Mount Palomar; on her instruction sheet the printed statement that "it is not feasible for women to undertake an observing program" was modified in pencil by the word "usually." Mount Wilson first admitted women as student observers in 1967. Cecilia Payne-Gaposchkin, who had been a full working member of the Harvard astronomy department and of the Observatory Council for thirty years, received full professorial rank at Harvard in 1956. Helen Sawyer Hogg became a full professor at the University of Toronto in 1957, twenty-six productive years after her Ph.D. In 1960 Mount Wilson promoted Margaret Burbidge to the rank of senior research fellow.

In the "big science" era that followed the Second World War, the quest for prestige discouraged the older, routine investigations in favor of more spectacular and immediately successful research. Moreover, the great celestial surveys undertaken about 1900 were all reaching completion. Coincidentally, the advent of electronic computers and scanning devices freed trained astronomers for more creative tasks.

In seeming contradiction, as astronomy has become more individualistic, some astronomers have given public acknowledgement of its cooperative aspects. In 1974, British astronomer Anthony Hewish got the Nobel Prize in Physics for his role in the discovery of pulsars, but the scientific press gave widespread attention to Jocelyn Bell, his graduate student who actually made the find.

In summary, the American astronomical community and the women's movement grew to maturity at about the same time, and by 1920 there was a happy symbiosis between the two. Astronomy offered respectable and satisfying employment, which newly educated women were eager to accept. By the 1930s women were recognizing the cost of their victory. Routine, low-status jobs were often presented and accepted as women's work, and most women interested in astronomy had chosen between career and marriage. Only in the past twenty years has there been a serious and somewhat successful effort to get women astronomers into gender-free educational, employment, and research opportunities, and to get men to share the tasks of family maintenance and nurture, so that both men and women might enjoy the challenges and rewards of both worlds. □

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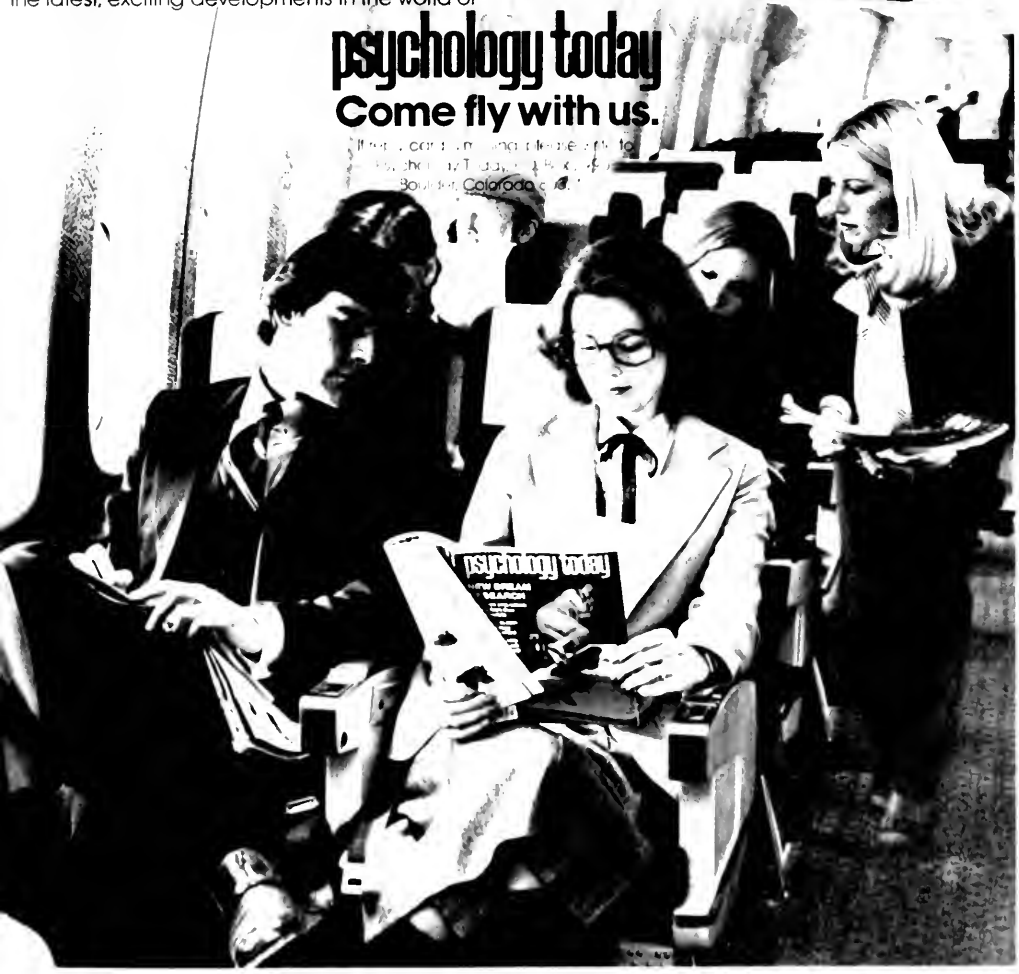

Mickey Mouse Meets Konrad Lorenz

Both animal behaviorists and Walt Disney have made similar discoveries about our responses

Age often turns fire to placidity. Lytton Strachey in his incisive portrait of Florence Nightingale writes of her declining years:

> Destiny, having waited very patiently, played a queer trick on Miss Nightingale. The benevolence and public spirit of that long life had only been equalled by its acerbity. Her virtue had dwelt in hardness. . . . And now the sarcastic years brought the proud woman her punishment. She was not to die as she had lived. The sting was to be taken out of her; she was to be made soft; she was to be reduced to compliance and complacency.

I was therefore not surprised—although the analogy may strike some people as sacrilegious—to discover that the creature who gave his name as a synonym for insipidity had a gutsier youth. Mickey Mouse turned a respectable fifty last year. To mark the occasion, many theaters replayed his debut performance in *Steamboat Willie* (1928). The original Mickey was a rambunctious, even slightly sadistic fellow. In a remarkable sequence, exploiting the exciting new development of sound, Mickey and Minnie pummel, squeeze, and twist the animals on board a steamboat to produce a rousing chorus of "Turkey in the Straw." They honk a duck with tight embrace, crank a goat's tail, tweak a pig's nipples, bang a cow's teeth as a stand-in xylophone, and play bagpipe on her udder.

Christopher Finch, in his semiofficial pictorial history of Disney's work, comments: "The Mickey Mouse who hit the movie houses in the late twenties was not quite the well-behaved character most of us are familiar with today. He was mischievous, to say the least, and even displayed a streak of cruelty" (*The Art of Walt Disney*, 1975). But Mickey soon cleaned up his act, leaving to gossip and speculation only his unresolved relationship with Minnie and the status of Morty and Ferdie. Finch continues: "Mickey . . . had become virtually a national symbol, and as such he was expected to behave properly at all times. If he occasionally stepped out of line, any number of letters would arrive at the Studio from citizens and organizations who felt that the nation's moral well-being was in their hands. . . . Eventually he would be pressured into the role of straight man."

As Mickey's personality softened, his appearance changed in tandem. Many Disney fans are aware of this transformation through time, but few (I suspect) have recognized the coordinating theme behind all the alterations—in fact, I am not sure that the

As Mickey became increasingly well behaved over the years, his appearance became more youthful. Measurements of three stages in his development (see graph, page 34) revealed a larger relative head size, larger eyes, and an enlarged cranium—all traits of juvenility.

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Stage 1 Stage 2 Stage 3

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Woman: They're fine. My husband's a Mexican food freak. Even pans with baked-on refried beans get clean. But where did the sand come from?

Consultant: What does the sand look like?

Woman: Like...sand. In a puddle of water that didn't drain out of the teacup.

Consultant: If you're seeing "sand," it could be your dishwasher detergent hasn't dissolved. Do you have a cup with some "sand" in it now?

Woman: Right here by the phone.

Consultant: Does the "sand" look like detergent?

Woman: You mean this is detergent?!?

Consultant: Look closer.

Woman: It does look like detergent. So why didn't it dissolve?

Consultant: Check your water temperature. At your dishwasher, it should be at least 140°. If it's okay, then I suggest you buy a fresh box of detergent. Dishwasher detergent sometimes has a very short shelf life and doesn't dissolve completely when it's old. And make sure you load your teacups properly, so all the water drains out.

Woman: Wow. You really helped. Sorry I bothered you, but at least I didn't have to call a repairman. Thanks for your time.

Consultant: Glad I could help.

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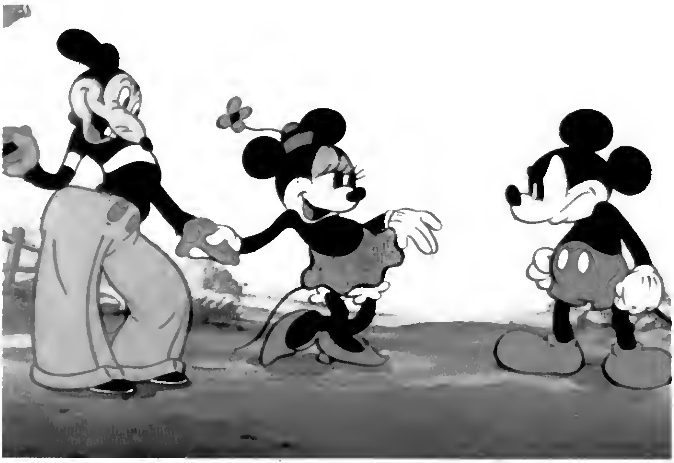


Dandified, disreputable Mortimer (here stealing Minnie's affections) has strikingly more adult features than Mickey. His head is smaller in proportion to body length; his nose is a full 80 percent of head length.

Disney artists themselves explicitly realized what they were doing, since the changes appeared in such a halting and piecemeal fashion. In short, the blander and inoffensive Mickey became progressively more juvenile in appearance. (Since Mickey's chronological age never altered—like most cartoon characters he stands impervious to the ravages of time—this change in appearance at a constant age is a true evolutionary transformation. Progressive juvenilization as an evolutionary phenomenon is called neoteny. More on this later.)

The characteristic changes of form during human growth have inspired a substantial biological literature. Since the head-end of an embryo differentiates first and grows more rapidly in utero than the foot-end (an antero-posterior gradient, in technical language), a newborn child possesses a relatively large head attached to a medium-sized body with diminutive legs and feet. This gradient is reversed through growth as legs and feet overtake the front end. Heads continue to grow but so much more slowly than the rest of the body that relative head size decreases.

During human growth, a suite of changes pervades the head itself. The brain grows very slowly after age three, and the bulbous cranium of a young child gives way to the more slanted, lower-browed configuration of adulthood. The eyes scarcely grow at all and relative eye size declines precipitously. But the jaw gets bigger and bigger. Children, compared with adults, have larger heads and eyes, smaller jaws, a more prominent, bulging cranium, and smaller, pudgier legs and feet. Adult heads are altogether more apish, I'm sorry to say.

Mickey, however, has traveled this ontogenetic pathway in reverse during his fifty years among us. He has assumed an ever more childlike appearance as the ratty character of *Steamboat Willie* became the cute and inoffensive host to a magic kingdom. By 1940, the former tweaker of pig's nipples gets a kick in the ass for insubordination (as the *Sorcerer's Apprentice* in *Fantasia*). By 1953, his last cartoon, he has gone fishing and cannot even subdue a squirting clam.

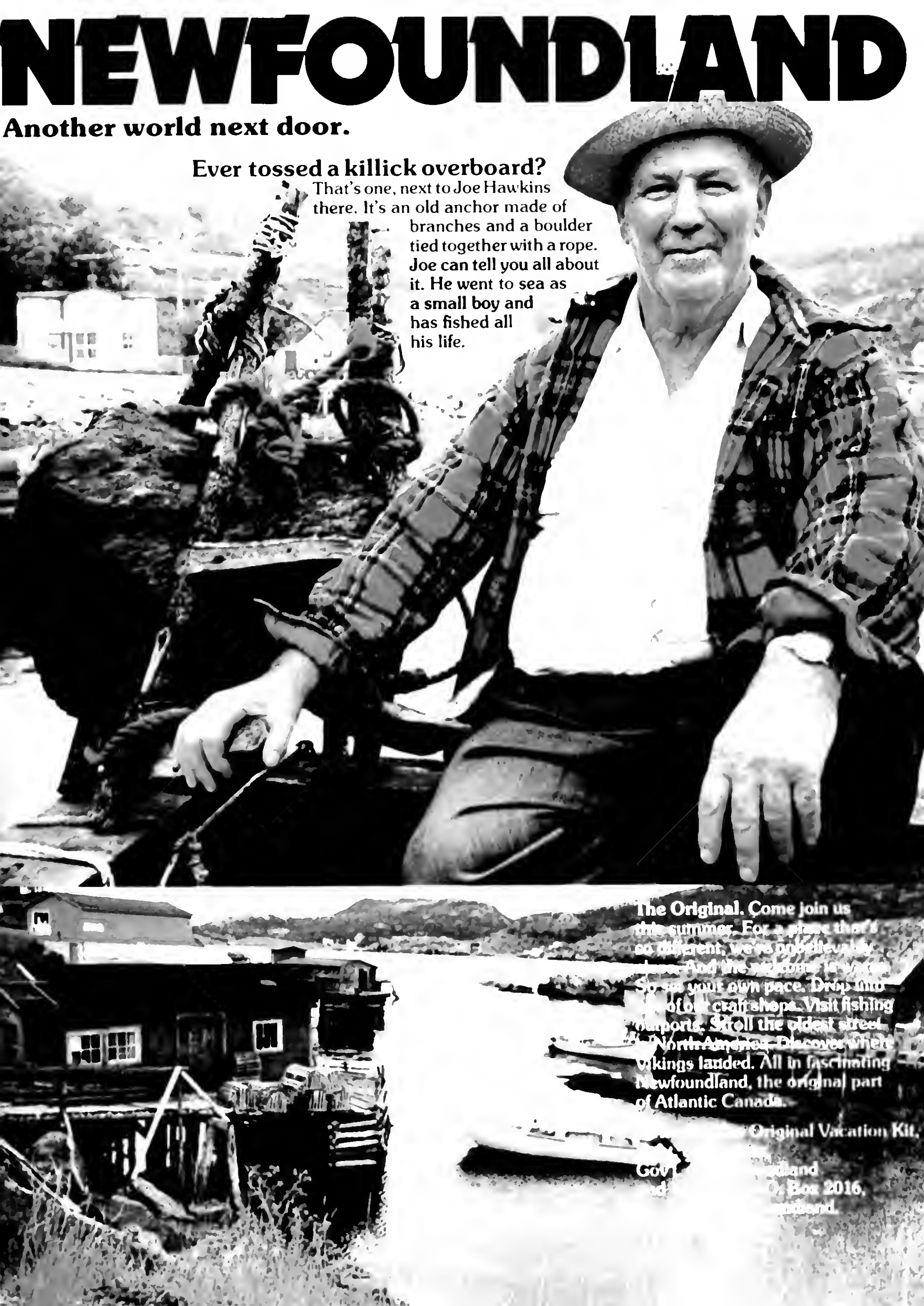
The Disney artists transformed Mickey in clever silence, often using suggestive devices that mimic nature's own changes by different routes. To give him the shorter and pudgier legs of youth, they lowered his pants line and covered his spindly legs with a baggy outfit. (His arms and legs also thickened substantially—and acquired joints for a floppier appearance.) His head grew relatively larger and its features more youthful. The length of Mickey's snout has not altered, but decreasing protrusion is more subtly suggested by a pronounced thickening. Mickey's eye has grown in two modes: first, by a major, discontinuous evolutionary shift as the entire eye of ancestral Mickey became the pupil of his descendants, and second, by gradual increase thereafter.

Mickey's improvement in cranial bulging followed an interesting path since his evolution has always been constrained by the unaltered convention of representing his head as a circle with appended ears and an oblong snout. Thus, the circle's form could not be altered to provide a bulging cranium directly. Instead, Mickey's ears moved back, increasing the distance between nose and ears, and giving him a rounded, rather than a sloping, forehead.

To give these observations the cachet of quantitative science, I applied my best pair of dial calipers to three stages of the official phylogeny—the thin-nosed, ears-forward figure of the early 1930s (stage 1), the latter-day Jack of Mickey and the Beanstalk (1947, stage 2), and the modern mouse (stage 3). I measured three signs of Mickey's creeping juvenility: increasing eye size (maximum height) as a percentage of head length (base of the nose to top of rear ear); head length as a percentage of body length; and increasing cranial vault measured by rearward displacement of the front ear (base of the nose to top of front ear as a percentage of base of the nose to top of rear ear).

All three percentages increased steadily—eye size from 27 to 42 percent of head length; head length from 42.7 to 48.1 percent of body length; and nose to front ear from 71.7 to a whopping 95.6 percent of nose to rear ear. For comparison, I measured Mickey's young "nephew" Morty Mouse. In each case, Mickey has clearly been evolving toward youthful stages of his stock, although he still has a way to go for head length.

You may, indeed, now ask what an at least marginally respectable scientist has been doing with a mouse like that. In part, fiddling around and having fun, of course. (I still prefer Pinocchio to Citizen Kane.) But I do have a serious point—two, in fact—to make. First, why did Disney choose to change his most famous character so gradually and persistently in the same direction? National symbols are not altered capriciously and market researchers (for the doll industry in particular) have spent a good deal of time and practical effort learning what features appeal to people as cute and friendly. Biologists also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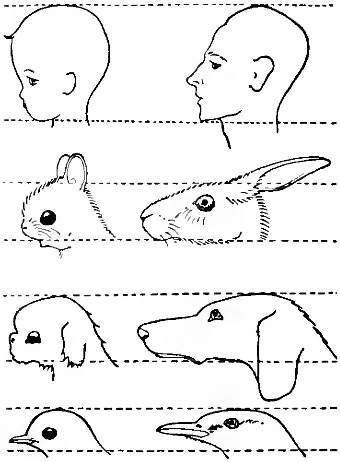


Humans feel affection for animals with juvenile features: large eyes, bulging craniums, retreating chins (left column). Small-eyed, long-snouted animals (right column) do not elicit the same response.

have spent a great deal of time studying a similar subject in a wide range of animals.

In one of his most famous articles, Konrad Lorenz argues that humans use the characteristic differences in form between babies and adults as important behavioral cues. He believes that features of juvenility trigger "innate releasing mechanisms" for affection and nurturance in adult humans. When we see a living creature with babyish features, we feel an automatic surge of disarming tenderness. The adaptive value of this response can scarcely be questioned, for we must nurture our babies. Lorenz, by the way, lists among his releasers the very features of babyhood that Disney affixed progressively to Mickey: "a relatively large head, predominance of the brain capsule, large and low-lying eyes, bulging cheek region, short and thick extremities, a springy elastic consistency, and clumsy movements."

I propose to leave aside for this article the contentious issue of whether or not our affectionate response to babyish features is truly innate and inherited directly from ancestral primates—as Lorenz argues—or whether it is simply learned from our immediate experience with babies and grafted upon an evolutionary predisposition for attaching ties of affection to certain learned signals. My argument works equally well in either case for I only claim that babyish features tend to elicit strong feelings of affection in adult humans.

Lorenz emphasizes the power that juvenile features hold over us, and the abstract quality of their influence, by pointing out that we judge other animals by the same criteria—although the judgment may be utterly inappropriate in an evolutionary context. We are, in short, fooled by an evolved response to our own babies, and we transfer our reaction to the same set of features in other animals.

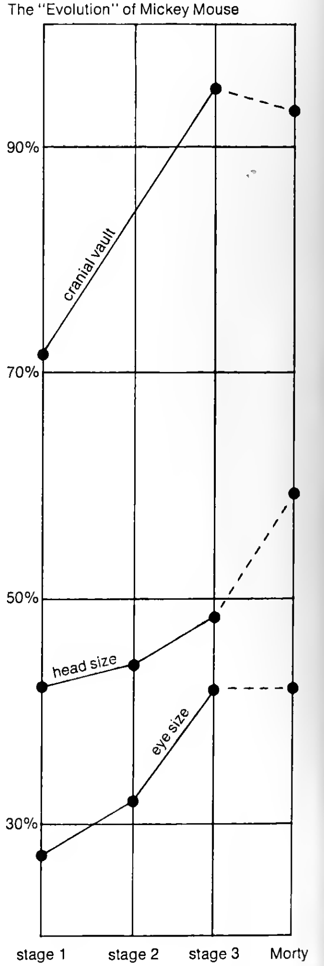
Many animals, for reasons having nothing to do with the inspiration of affection in humans, possess some features also shared by human babies but not by human adults—large eyes and a bulging forehead with retreating chin, in particular. We are drawn to them, we cultivate them as pets, we stop and admire them in the wild—while we reject their small-eyed, long-snouted relatives who might make more affectionate companions or objects of admiration. Lorenz points out that the German names of many animals with features mimicking human babies end in the diminutive suffix *chen*, even though the animals are often larger than close relatives without features similar to human babies—*Rotkehlchen* ("robin"), *Eichhörnchen* ("squirrel"), and *Kaninchen* ("rabbit"), for example.

In a fascinating section, Lorenz then enlarges upon our capacity for biologically inappropriate response to other animals, or even to inanimate objects, that mimic human features. "The most amazing objects can acquire remarkable, highly specific emotional values by 'experiential attachment' of human properties. . . . Steeply rising, somewhat overhanging cliff faces or dark storm-clouds piling up have the same, immediate display value as a human being who is standing at full height and leaning slightly forwards"—that is, threatening.

We cannot help regarding a camel as aloof and unfriendly because it mimics, quite unwittingly and for other reasons, the "gesture of haughty rejection" common to so many human cultures. In this gesture, we raise our heads, placing our nose above our eyes. We then half-close our eyes and blow out through our nose—the "harumph" of the stereotyped upper-class Englishman or his well-trained servant. "All this," Lorenz argues quite cogently, "symbolizes resistance against all sensory modalities emanating from the disdained counterpart." But the poor camel cannot help carrying its nose above its elongate eyes, with mouth drawn down. As Lorenz

In an early drawing (see page 30, stage 1) Mickey had a smaller head, cranial vault, and eyes. He evolved in stages toward the characteristics of his young nephew Morty (connected to Mickey by a dotted line).

The "Evolution" of Mickey Mouse



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reminds us, if you wish to know whether a camel will eat out of your hand or spit, look at its ears, not the rest of its face.

In his important book *Expression of the Emotions in Man and Animals*, published in 1872, Charles Darwin traced the evolutionary basis of many common gestures to originally adaptive actions in animals later internalized as symbols in humans. Thus, he argued for evolutionary continuity of emotion, not only of form. We snarl and raise our upper lip in fierce anger—to expose our nonexistent fighting canine tooth. Our gesture of disgust repeats the facial actions associated with the highly adaptive act of vomiting in necessary circumstances. Darwin concluded, much to the distress of many Victorian contemporaries: "With mankind some expressions, such as the bristling of the hair under the influence of extreme terror, or the uncovering of the teeth under that of furious rage, can hardly be understood, except on the belief that man once existed in a much lower and animal-like condition."

In any case, the abstract features of human childhood elicit powerful emotional responses in us, even when they occur in other animals. I submit that Mickey Mouse's evolutionary road down the course of his own growth in reverse reflects the unconscious discovery of this biological principle by Disney and his artists. In fact, the emotional status of most Disney characters rests on the same set of distinctions. And to this extent, the magic kingdom trades on a biological illusion—our ability to abstract and our propensity to transfer inappropriately to other animals the fitting responses we make to changing form in the growth of our own species.

Donald Duck also adopts more juvenile features through time. His elongated beak recedes and his eyes enlarge; he converges on Huey, Louie, and Dewey as surely as Mickey approaches Morty. But Donald, having inherited the mantle of Mickey's original misbehavior, remains more adult in form with his projecting beak and more sloping forehead.

Mouse villains or sharpies, contrasted with Mickey, are always more adult in appearance, although they often share Mickey's chronological age. In 1936, for example, Disney made a short entitled *Mickey's Rival*. Mortimer, a dandy in a yellow sports car, intrudes upon Mickey and Minnie's quiet country picnic. The thoroughly disreputable Mortimer has a head only 29 percent of body length, to Mickey's 45, and a snout 80 percent of head length, compared with Mickey's 49. (Nonetheless, and was it ever different, Minnie transfers her affection until an obliging bull from a neighboring field dispatches Mickey's rival.) Consider also the exaggerated adult features of other Disney characters—the swaggering bully Peg-leg Pete or the simple, if lovable, dolt Goofy.

As a second, serious biological comment on Mickey's odyssey in form, I note that his path to eternal youth repeats, in epitome, our own evolutionary story. For, as I have argued in several columns, humans are neotenic. We have evolved by retaining to adulthood the originally juvenile features of our ancestors. Our australopithecine forebears, like Mickey in *Steamboat Willie*, had projecting jaws and low vaulted craniums.

Our embryonic skulls scarcely differ from those of chimpanzees. And we follow the same path of changing form through growth: relative decrease of the cranial vault since brains grow so much more slowly than bodies after birth, and continuous relative increase of the jaw. But while chimps accentuate these changes, producing an adult strikingly different in form from its baby, we proceed much more slowly down the same path and never get nearly so far. Thus, as adults, we retain juvenile features. To be sure, we change enough to produce a notable difference between baby and adult, but our alteration is far smaller than that experienced by chimps and other primates.

A marked slowdown of developmental rates has triggered our neoteny. Primates are slow developers among mammals, but we have accentuated the trend to a degree matched by no other mammal. We have very long periods of gestation, markedly extended childhoods, and the longest life span of any mammal. The morphological features of eternal youth have served us well. Our enlarged brain is, at least in part, a result of extending rapid prenatal growth rates to later ages. (In all mammals, the brain grows rapidly in utero but often very little after birth. We have extended the operation of this fetal rate.)

And the changes in timing themselves have been just as important. We are preeminently learning animals, and our extended childhood permits the transference of culture by education. Many animals display flexibility and play in childhood but follow rigidly programmed patterns as adults. Lorenz writes, in the same article cited above: "The characteristic which is so vital for the human peculiarity of the true man—that of always remaining in a state of development—is quite certainly a gift which we owe to the neotenous nature of mankind."

In short, we, like Mickey, never grow up although we, alas, do grow old. Best wishes to you, Mickey, for your next half century. May we stay as young as you, but grow a bit wiser.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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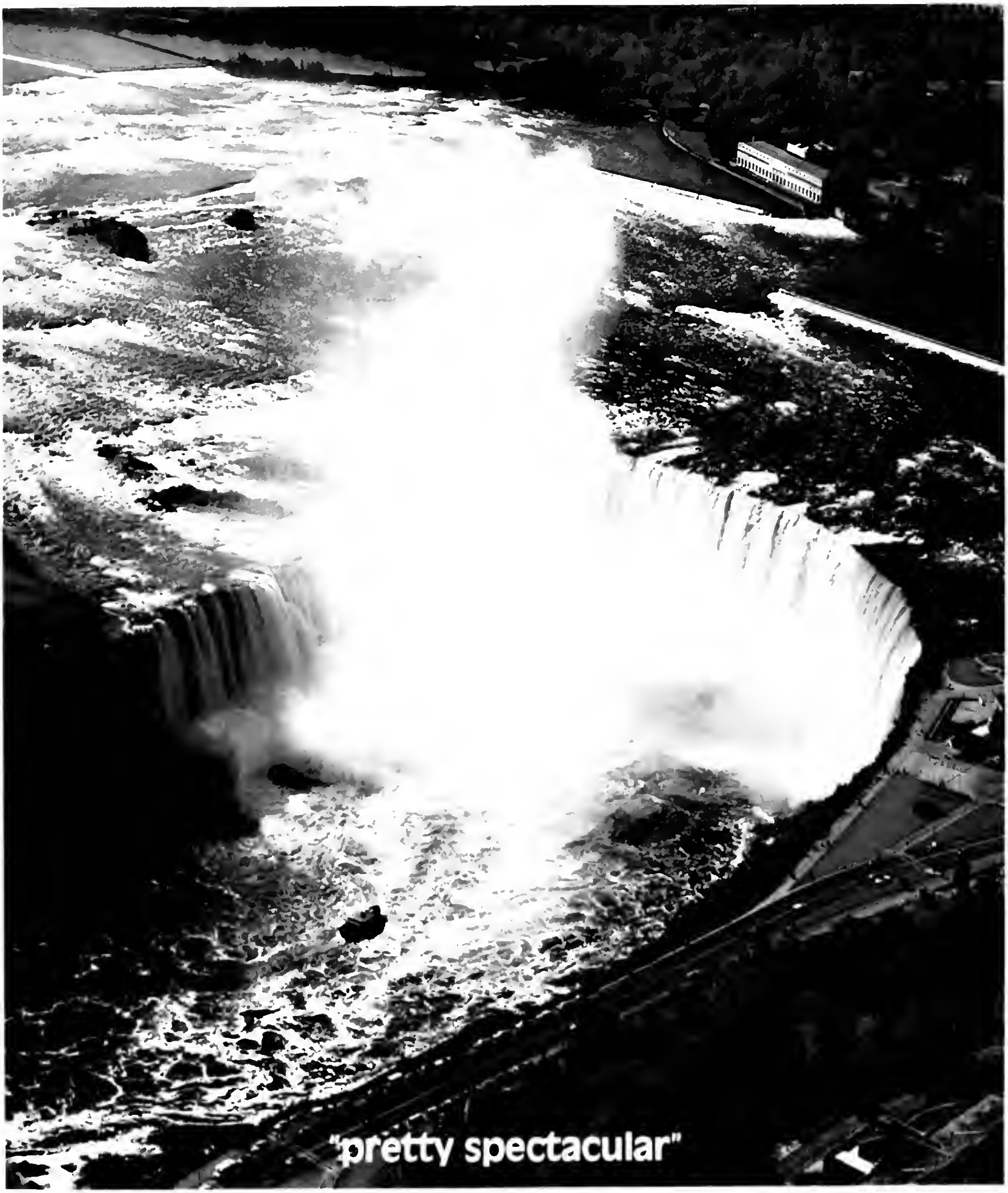
Cartoon villains are not the only Disney characters with exaggerated adult features. Goofy, like Mortimer, has a small head relative to body length and a prominent snout, but he is depicted as an appealing numskull.



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Debut of the Seventeen-Year-Old Cicada

This spring, brood II of the longest-lived insects will burst forth from the ground right on cue. Soon thereafter, they will "disappear" for another seventeen years

by Chris Simon

The periodical cicada is due to make an appearance this year over a wide area of the eastern seaboard—from central North Carolina to the mid-Hudson Valley. The parents of this year's generation emerged from the ground in late May 1962: first in North Carolina; later, farther north. During the intervening seventeen years, the offspring of those insects have grown from approximately six-hundredths of an inch to one inch in length.

Periodical cicadas, the subject of natural history investigations since the mid-seventeenth century, have recently proved a useful tool in studying evolutionary ecology and the problems of speciation. The most commonly asked questions about these cicadas are: Why do they emerge every seventeen years? Why do they live longer than any other insect? Why do they occur in tremendous numbers? Why are the adults synchronized in emergence time? Why don't they appear in the same year everywhere? And what do they do during their seventeen years underground? As is usually the case in scientific inquiry, the more we learn, the more interesting questions arise.

Commonly known as "seventeen-year locusts" because of their habit of emerging in plague proportions every seventeen years, periodical cicadas first received the name "locusts" in 1634 from the Pilgrims, who mistakenly equated them with the migratory grasshoppers of Biblical plagues. Since that time, both periodical and nonperiodical cicadas have been called locusts, a misnomer that has caused confusion and unnecessary panic.

True locusts are short-horned (antennaed) grasshoppers that belong to the insect order Orthoptera, along with katydids, mantids, and roaches. They possess chewing mouthparts and can destroy crops. Seventeen-year locusts are actually cicadas and belong to the order of sucking insects, Homoptera, which includes spittlebugs, leaf hoppers, aphids, scale insects, and mealybugs. The damage they cause to vegetation is considerably less severe.

Cicadas are worldwide in distribution, comprising 265 genera and 1,940 species. The diversity is immense. They range in wingspan from a little more than an inch to approximately 7½ inches. Some are brightly colored, but many are dull brown or green. The more curious species include the bladder cicadas, with their large balloonlike abdomens, and the hairy cicadas, which inhabit the cooler regions of Australia. Male cicadas are noted for their singing ability. The song is produced most commonly by the vibration of a tight, ribbed membrane (tymbal), which is moved by a pair of large muscles. However, there are species that produce sound by stridulating (with a file and scraper) or by banging their wings.

The periodical cicadas, which make up the genus *Magicicada*, occur in the United States east of the Great Plains. In addition to the seventeen-year life cycle form, a thirteen-year form inhabits the South and the Midwest. The latter was not recorded in the literature until the mid-1800s, fully 200 years after the first published reference to the seventeen-year cicada. All other cicada genera are nonperiodical: they may have long life cycles (up to seven to nine years) but they are unsynchronized, so that some individuals mature and emerge every year.

Periodical cicadas are easily distinguishable from their annual relatives as they are the only North American cicadas with red eyes and they generally emerge earlier, in May and June as opposed to July and August. Like other cicadas, the females lay their eggs in slits in tree branches using their sharp, sawlike ovipositors. The eggs hatch after one and a half to two months and hundreds of thousands of tiny millimeter-long nymphs instinctively launch themselves into space. The majority land within a few acres of where their grandparents emerged from the ground thirteen or seventeen years before. There they burrow underground and use their needlelike beaks to pierce tree rootlets and feed on dilute xylem fluid. When the rootlet dies, they search for a new one.

The subterranean nymphs pass through five stages (instars), growing with each intermediary molt. The fifth-instar nymphs emerge synchronously in a given locality, usually at dusk, often within a week or two of the emergence of their forebears 17, 34, 51 years before (or 13, 26, 39, in the thir-

After emerging from a seventeen-year underground existence, a periodical cicada will climb any nearby vertical surface. Its aboveground life is brief; in three to four weeks it will have mated and died.

S. J. Krasemann

Karl H. Maslowski,
Photo Researchers

Chris Simon

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teen-year race). When densities are particularly high, emergence may continue into the day or over a period of days.

How the nymphs "count" the years is unknown. They do not all grow at the same rate. The approximate durations of the stages are one-half to one year in the first instar; two to six years in the second (probably two years in the thirteen-year cicada and up to six years in the seventeen-year cicada); three to four years in the third; three to four years in the fourth; and the remaining time in the fifth. Thus at any given time, two or three different instars might exist in a population. Within an instar, body size may vary depending on nutrition.

Despite varying growth rates, at the end of the allotted time all nymphs are in the fifth instar. They may construct an exit tunnel as much as a month (or even a year) early and sit just below the surface. The final precision that marks the date of emergence is impressive but less difficult to explain than the counting of the years. The crucial factor is the sum of cumulative degree days of soil temperature in the spring. James Heath, an insect physiologist at the University of Illinois, studying an emergence on a north- and south-facing wooded slope, found that a 64°F ground temperature seemed to be the final cue. Others have noticed that emergences often follow heavy rains.

Hundreds of thousands of fifth-instar nymphs emerge from the ground just after sunset and head for the nearest vertical object, which they climb. The distance they climb before eclosing depends on the object they

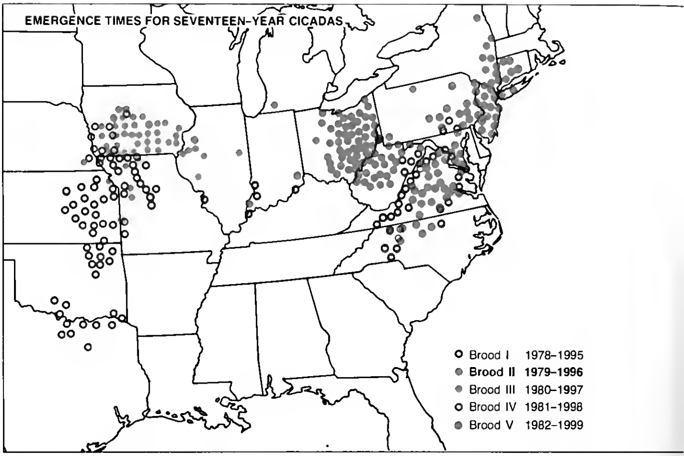
The exit holes of seventeen-year cicadas, top, dot the floor of a woods in Hamilton County, Ohio. Near Vicksburg, Mississippi, a newly emerged nymph of brood XXIII of the thirteen-year cicada is crawling toward a nearby tree to begin its life as an adult, center. A day after the cicadas have emerged, the base of a tree, bottom, is littered with castoff nymphal skins, dying cicadas unable to make it any farther because of injury, and a few stragglers on the ascent. Hanging from a twig, a thirteen-year cicada, right, stretches back and out of its nymphal jacket.

happen to have climbed (for example, a tall tree versus a grass stem) and probably on the level of their stored energy reserves.

The transformation to the adult stage is spectacular. The dry, golden skin, in which a nymph has been imprisoned for the previous four to eight years, splits down the back to reveal a milky white creature with bright red eyes and two square, black patches on its back (believed to be involved in the attachment of the muscles of the forelimbs). The wings, which up to this point have been folded accordianlike, are now free to expand. This is accomplished by the pumping of hemolymph through the wing vein network. The transformation may take several hours and includes hardening and darkening of the cuticle. The length of this vulnerable stage in the life cycle suggests an adaptive explanation for their dusk-timed emergence—escape from visually orienting avian predators.

By midnight, new adults can be found clinging to tree limbs, branches, blades of grass, or any other vertical object that can support their weight. Instinctively they climb upward; their wings are still too soft and the night temperature is too cool for flight. By midday the cicadas have hardened and warmed up and are capable of flight, but activity levels are generally low until the second or third day when the males begin their mating song. They prefer sunny places such as tree tops and by the end of the first week a prominent tree often becomes a chorusing center. The females fly here to mate, then disperse over short distances to lay eggs. The adults live for three to four weeks.

Egg laying can be destructive to vegetation. When densities are highest, the slits into which the eggs are laid can damage branch tips beyond repair. Although a heavy infestation may leave a forest looking brown, the ultimate effect on most trees is no more severe than a good pruning. Smaller trees, however, can be killed. When forewarned, orchard growers often plan ahead and do not plant new trees for three or four years prior to a predicted emergence. Homeowners are advised to shake cicadas off young trees or to cover them with cheesecloth. Spraying large trees with insecticides is an expensive, dangerous, and useless exercise as the spray must contact cicadas directly to be effective. Furthermore, dying cicadas that have not escaped the poison flutter on the ground where they are eaten by unsuspecting birds, dogs, and cats.



One of the most dramatic aspects of the periodical cicada's appearance is the immensity of its populations. Often every square foot of the emergence area is pockmarked with their holes. Cicadas and empty nymphal shells can be found clinging everywhere. This immense pulse of life, preceded and followed by seventeen years of its absence, insures that no predators can specialize. The cicada strategy for survival is predator satiation, rather than predator avoidance.

Periodical cicadas cannot bite or sting. They are conspicuous, good tasting, and not always quick to fly when disturbed. These characteristics were collectively termed "predator foolhardiness" by Monte Lloyd and Henry Dybas, two evolutionary biologists who study the complex evolutionary history of the group. They pointed out that a direct consequence of this strategy is that population sizes *must* be large in order to avoid localized extinction through predation.

Rick Karban, an energetic field biologist from the University of Pennsylvania who is studying predator satiation, censused periodical cicada populations in Virginia last spring. He estimated the initial density of a population by counting emergence holes and later measured the same population's survival and reproductive success by intercepting its falling first-instar offspring in trays placed under their nest trees. His findings showed that survival, estimated by reproductive output, increased more than proportionately with population density; that is, dense populations produced relatively more offspring, presumably because a smaller proportion of the total population was eaten by predators.

Many nonperiodical cicada species fluctuate in adult abundance from summer to summer; that is, they have "good" and "bad" years. To create periodicity from such a situation, there must be natural selection against individuals emerging in years when population densities are low. The ancestral "protoperiodical" cicadas most likely had a shorter life cycle than their modern periodical relatives since all known nonperiodical cicadas have life cycles within the range of three to nine years and most other insect species have life cycles of one year or less. Seventeen years is the longest known life cycle (egg to adult) of any insect.

The classical ecological theory of predator buildup as a response to increasing prey abundance can be applied to this situation. Imagine an ancestral protoperiodical cicada species that fluctuates in adult abundance from year to year. In years when many adult cicadas succeed in emerging, the predators and parasites of these insects will feed well and produce many offspring, so the predator population will increase. Because cicadas that emerge the following year face increased predation pressure, each individual has a high probability of death. Therefore there would be selection for individual cicadas to emerge in years of high absolute cicada density. In such a situation, the probability of any one cicada being eaten is very low.

This predator-satiation strategy is not unique to cicadas. Some dragon-

The author requests that readers who see any of this year's brood, due to emerge in May and June, send her a post card with the following information:

Your name and address
Exact location and date of sighting
Number of species present (if possible)

Address cards to:

Chris Simon
Dept. of Ecology and Evolution
State University of New York
Stony Brook, New York 11794

This information will be used in precisely locating cicada populations and in helping to make distribution maps.

flies and June beetles, temperate oak trees, many tropical fruit trees, and Asian bamboos all follow the same strategy. An important component of this predator escape device is that in intervening years, prey availability must be minimal, so that predator populations drop to low levels (because of starvation) before the next pulse of prey.

Lloyd and Dybas have suggested that periodical cicadas have long life cycles as the result of an "evolutionary race through time" between the protoperiodical cicadas and a specialized parasitoid (a parasite that kills its prey). This hypothetical parasitoid presumably had a life cycle that was almost synchronized with, and nearly equal in length to (but always slightly less than), the ancestral protoperiodical cicada. As the theory goes, the cicadas finally outran their parasitoid pursuer and the poor specialized beast went extinct. The theory is tenuous in that its proof is the nonexistence of the hypothetical parasitoid. Nevertheless, no more plausible theory exists.

Once a long life cycle is achieved, the perfection and maintenance of periodicity is "easy." This mathematical problem was explored by Frank Hoppensteadt and Joseph Keller of New York University's Courant Institute of Mathematical Sciences. They demonstrated that predation and environmental carrying capacity can act in combination to bring about perfect synchrony. Synchronization is a consequence of the opposing pressures of a limiting environmental resource (in this case oviposition and nymphal feeding sites) and the numbers of adult cicadas needed to satiate predators. When supplied with estimates of population size, fecundity, environmental carrying capacity, nymphal survival rate, and predator population size, the mathematical model predicted that cicadas with a generation time of less than ten years would be nonsynchronized and appear annually, whereas cicadas with longer life cycles would become periodical. Other parametric values could yield a different threshold for periodicity, but the general conclusion would be the same: long life cycles result in synchrony (periodicity).

Why then don't we see periodical cicadas with life cycles of, for example, twelve, fourteen, fifteen, sixteen, or eighteen years? Lloyd and Dybas have suggested that a prime number of years between emergences insures that no predators can track the cicada population by having cycles half as long and catching them every other time, or a third as long and catching them every third time, and so on. Thirteen and seventeen are prime numbers; therefore, unless the predator has a life cycle equal in length to the cicadas, the minimum number of years between predator and cicada coincidence is equal to the length of the predator's life cycle times the length of the cicada's life cycle.

Although a given population of cicadas emerges only once every thirteen or seventeen years, the thirteenth or seventeenth year differs from place to place in the eastern United States. This is because subsections of the original ancestral population somehow became displaced over time. All populations that emerge in the same year are members of a brood; a brood is simply a year class. Broods are numbered sequentially according to their year of emergence. For example, brood I adults appeared last year, II this year, and III will appear next year. Any brood numbered XVII or less is a seventeen-year brood; a brood numbered from XVIII through XXX is a thirteen-year brood. Fourteen broods of seventeen-year cicadas (at the turn of the century there were sixteen) and five broods of thirteen-year cicadas are thought to exist at the present time.

A brood is often considered to represent a loose evolutionary unit; all populations in a brood are most likely more closely related to each other than to populations occurring in other years. Some broods are large and occupy most of the eastern United States, others are small and occupy only a small corner of a state. Broods that overlap in distribution are always separated by at least four years in adult emergence time. This overlap presumably developed well after the establishment of periodicity and the demise of the hypothetical parasitoid. Adjacent broods are often separated in time by a single year.

Evidence suggesting that broods are indeed coherent units is relatively recent. My own work centers on this problem. We now know that despite the apparent superficial similarity of all broods, the members of any given brood possess more characteristics in common than they share with cicadas of other broods. These characteristics, which include the biochemical structure of their metabolic enzymes and the external shape of their body parts, can be used to construct evolutionary trees that represent the pattern of breakup of the broods of periodical cicadas.

To complicate matters, there are three morphologically distinct species of periodical cicada. Each of these is represented by thirteen- and seventeen-year life cycle forms. The largest and most common of the periodical cicadas is *Magicicada septendecim;* its thirteen-year counterpart is named *M. tredecim.* They are collectively abbreviated "Decim." The other two morphologically distinct periodical cicadas are smaller. They were lumped together and called "the dwarf form of the periodical cicada" until 1962, when Tom Moore and Richard Alexander, of the University of Michigan Museum of Zoology, demonstrated that each had a distinct mating song and unique coloration. The two smaller periodical cicadas have been named *M. cassini* (*M. tredecassini*) and *M. septendecula* (*M. tredecula*), abbreviated "Cassini" and "Decula," respectively. Cassini has a black abdomen and black tips to its legs. Decula's abdomen is black with orange stripes, while its tarsi are orange; and Decim's abdomen is entirely orange or orange-striped and its tarsi, black. In addition, Decim has a reddish patch just behind each eye.

Most broods contain all three morphologically distinct species. Decim is by far the most abundant and extends farther north than the other two species. Cassini is locally abundant in the Midwest and has its greatest densities in river bottomlands. Decula is much more common in the South than in the North but is always less abundant than the other two and never occurs alone

Steve McDaniel Tom Stack and Associates

Two seventeen-year cicadas mate on a maple tree in Towson, Maryland. This photograph was taken in 1970, so the pair belongs to brood X. The offspring from this mating will appear in 1987.

The three species can be identified in the field most easily by their songs. Decim's song is a hollow *pharooooh*, dramatically dropping in frequency at the end of each burst. A large chorus sounds remarkably like a fleet of flying saucers from a late fifties science fiction movie. Cassini's song is a series of *tics*, which increase in frequency and end in a loud buzz. The deafening roar of a synchronized Cassini chorus at midday is unforgettable. Decula produces a steady, tambourinelike cadence—*tschh-tschh-tschh-tschh*.

The differences in their mating songs serve to keep the species distinct. JoAnn White, an ecologist from the University of North Carolina, performed experiments in which she forced Decim, Decula, and Cassini to interbreed. White obtained hybrid eggs that later hatched into intermediate-sized nymphs. This result was not unexpected; many closely related species can interbreed. She credited the integrity of the species to the strong, behaviorally isolating influence of their unique songs. The lack of any physiological barriers to interbreeding indicated a relatively recent origin.

Few evolutionary biologists would deny that Decim, Cassini, and Decula represent distinct species, but there has been considerable debate over whether thirteen- and seventeen-year life cycle forms should be considered separate species. The biological species concept requires that separate species must not be potentially interbreeding. Thirteen- and seventeen-year forms will interbreed freely when placed together: there are no behavioral differences between them. In nature, a thirteen-year and a seventeen-year brood have the possibility of meeting every 221 years if they overlap in distribution. A few thirteen- and seventeen-year broods overlap geographically; when they do, however, they are rarely, if ever, found in the same patch of woods. From that point of view thirteen- and seventeen-year cicadas might well be called different species. But on that line of reasoning, every brood or local isolated population would qualify as a species and their taxonomy would be unreasonably complex. Clearly, the biological species definition leaves much to be desired.

Rather than arguing over species definitions, researchers are trying to understand how and why species differ. In an attempt to quantify the biochemical differences among species, evolutionary biologists have analyzed protein differences among classically defined (reproductively isolated and usually morphologically distinct) species and geographically isolated local populations of the same species. I have analyzed protein differences among the periodical cicadas and have found that compared with many other species, the morphologically distinct Decim, Cassini, and Decula are on the high end of the similarity scale. Since the three morphologically distinct species became reproductively isolated, they have accumulated very few amino acid or protein structural differences. Thirteen- versus seventeen-year forms of each of these species are even more similar: the level of variation among them is equivalent to the amount of differentiation that has occurred among local populations of most other organisms known. The various broods of a given morphologically distinct species are as distinct from each other as are any of the thirteen- versus seventeen-year forms. Local populations, in general, have not become differentiated.

Using her slender ovipositor, a seventeen-year cicada deposits her eggs in a slit in a tree branch. In one and a half to two months, the eggs will hatch and the nymphs will flutter to the ground.

There is no doubt that the numbers of periodical cicadas are dwindling in some places. Two broods are extinct: brood XI, which at one time occupied the Connecticut River Valley, and brood XXI, which used to occur along the Mississippi-Alabama border and in the Florida panhandle. The remaining broods have not decreased significantly in range, but they are made up of fewer and fewer local populations. As with most organisms, the greatest threat to the species is habitat destruction; the only sure cure for their decline is increased public awareness.

We have come a long way in our scientific understanding of the complex evolutionary relationships of the broods and species of periodical cicadas, yet they remain a needlessly misunderstood and unappreciated mystery to the majority of the people who encounter them. In the thousands of miles I have traveled in search of the periodical cicadas, I have experienced a wide variety of reactions to them. In the South, they were treated as a noisy but interesting curiosity, a reminder of childhood adventures, while many Midwesterners seemed disinterested or mildly inconvenienced by them. Northeasterners were often openly hostile or frightened; some were out to poison every last cicada, others locked themselves in their suburban homes and called the fire department.

Regional stereotyping aside, the periodical cicadas have, in general, not received the appreciation they deserve. They are the longest lived of any insect and exhibit the most precise synchronization; they occur nowhere else in the world, and their complex distribution pattern is a scientific puzzle that, when solved, will be a key contribution to understanding the speciation process. □

How Wolves Kill

Skill and strategy are needed to bring down large-sized prey

by Durward L. Allen

There is a universal reality in the natural world. All living things are destined to die and to be recycled as part of the flow of energy through the life community. Which is to say, a creature must feed, and sooner or later, it will be fed upon.

According to the longstanding ecological plan, some species subsist on plants. They reproduce abundantly, their lives are brief, and the yearly turnover of numbers is massive. The bulk of these typical prey animals have their careers cut short. At an early age they contribute their substance to the direct support of the meat eaters. Eventually it happens to the more durable, older individuals, those that live long enough to breed—and to the predators themselves. Anything not eaten at once will disintegrate into the soil by way of various decay and scavenging organisms.

For any creature it is a concern of living to put off the recycling as long as possible. But biological accounting is not to be denied, and even the carnivores are subject to an early weeding-out. Thus, the young of every kind—chicks, nestlings, fawns, calves, cubs, pups—are a part of the communal food supply and their numbers will be drastically reduced in the natal year. Those that survive to produce another generation are the select few that continue the slow evolutionary course toward a more competitive level of adaptation.

The dominant feature of this regime is that nature gives short shrift to the weak, the incompetent, the disadvantaged, and the unlucky. The effect of the plan is plainly evident: it preserves the species. For himself, of course, man has disavowed the system, and we are waiting to see how it works when the individual comes first.

Many of the hoofed prey animals associate in bands and herds that can be sorted conveniently for vulnerable individuals by the carnivores they nourish. Typical of the more social ungulates are antelope, bison, caribou, and horses. Some of the carnivores also are organized for action, notably the wolf, wild dog, and hyena. In lesser degree this is true of the lion and cheetah, and we probably should add the coyote. Typical solitary hunters are the leopard, mountain lion, and lynx.

Except for seasonal "family" groups and loose associations of several adults, the moose is a solitary prey animal. The cow protects her calf, but otherwise there is no mutual defense. Adult moose outweigh adult wolves by roughly ten to one. Over geologic time, hunting methods of the wolf have adjusted to the protective strategies of its various prey species, which also were undergoing change. So wolves can kill moose of certain categories. The rules are not hard and fast, however, because wolves vary, moose vary, and situations vary. In observing the hunting methods of Michigan's Isle

A pack of wolves is about to overtake a moose on the trail. The initial attack, usually from the rear, is most often led by the more experienced members of the pack, who close in from opposite sides.

Excerpted from the book *Wolves of Minong*, by Durward L. Allen, by permission of the publisher Houghton Mifflin. Copyright ©1979 Durward L. Allen.

Royale wolves we have seen much evidence of skill and competence and possibly an occasional example of malpractice.

It is a fair guess that the behavioral pattern by which a moose avoids immediate recycling is more stereotyped than the battle plans by which the wolf pack harvests its next meal. My logic is that the moose needs a largely inborn mode of reaction to attack because it gets only occasional emergency drills that call for defense. And like a parachute jumper, it must be right the first time. On the other hand, wolves get regular practice at dealing with their large, intractable prey, and they miss frequently.

The predator probably inherits a more general program of physical and behavioral capabilities. This genetic score must then be orchestrated through a training regimen that includes puppish play, example, experience, and quite possibly, handed-down pack traditions. In dealing with a moose, the single wolf must be largely a scavenger, but the pack can kill. The senses, abilities, and techniques the pack brings to this job have been revealed in part during the eighteen years we have watched things happen.

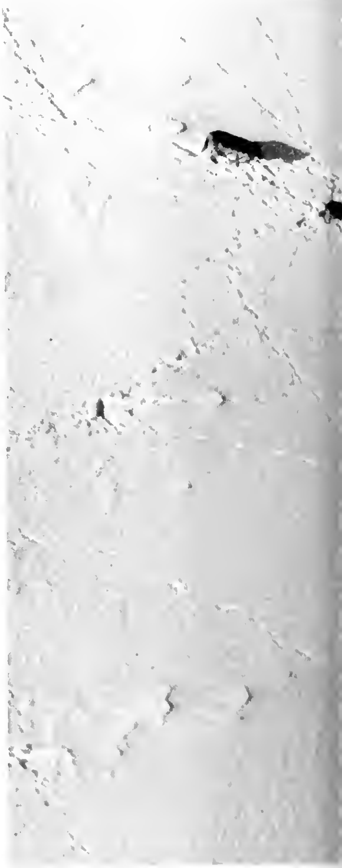
Although the Isle Royale wolf population has undergone a total turnover of individuals, and new packs under new leadership have been organized during the period of study, hunting and killing methods have remained the same. They conform to observations of recent years made by workers in Ontario, Minnesota, Alaska, and elsewhere. Compared with the state of our knowledge twenty years ago, a great deal has been learned in North America about how the wolf detects and handles its prey.

All canids are keen of nose, and it has been demonstrated many times that wind-borne scents play an important part in prey seeking by the wolf. As for actual scent tracking, wolves use it in following one another, but it is not important as a hunting technique in winter. We have no knowledge of the extent to which it is used in summer, when it probably could have greatest value.

Moose break many trails through the snow, which traveling wolves follow days or weeks after they are made. This is a matter of convenience, although when the pack crosses a fresh moose track, it could be diverted into stalking the animal. In an area of many tracks, scent should be an aid in staying with the correct one and locating the moose without regard to wind direction. However, nose-to-the-snow tracking for long distances is not seen; there are easier and more direct ways to find a moose.

Although wolves live in a world of scents, their eyesight is also good, and they become aware of any motion at a long distance. Anyone working with animals in the wild—observing, hunting, or photographing them—has long since discovered that most creatures have little or no perception of form, but they react quickly to motion. A move toward or away from an animal is less likely to be picked up than one in a lateral direction. In many situations the best camouflage is to sit in front of the cover rather than to hide behind it. The stalker's necessary movements should be made with great deliberation—literally, an inch at a time—with full advantage taken of intervals when the observed animal's head is down or turned away, or when it is moving and its head passes closely behind a tree. The watcher can change position quickly in the instant the animal's vision is blocked. The faster an animal is passing through vegetation, the less likely it is to see motion at a distance. Anyone can easily check this: the best chance of seeing something is to sit immobile until the eye picks up a movement. When a breeze is fluttering the leaves, slight movements are less likely to be detected, as are sounds.

It should be realized that the eyesight of the wolf and, for that matter, of all its mammalian prey, is not aided by color vision. Although fishes, reptiles, and birds usually have excellent color perception, in mammals this ability is well developed only among the primates (mainly monkeys, apes, and humans). Color vision is an adaptation of animals usually abroad in daylight. As birds well demonstrate, they commonly react to their own gay hues, as well as to those of fruits, insects, and other things they feed upon. The environment of wolves and most other mammals is seen in shades of gray, largely distinguished by varying degrees of brightness. The majority of mammals are nocturnal, and even humans do not see color when they are abroad at night. To the vertebrate eye, colors lose their value in dim light. But even in sunny midday, the wolf sees a hiker wearing a red pack in about the same tones as one wearing a poncho in the rain.



When traveling on an icy shoreline or the firm snow of a frozen lake, the wolf pack commonly is scattered out in a long line, with individuals or groups of two or three taking slightly different routes. A worker on foot can count the tracks easily under these conditions. As we follow them from the air, the dominant pair usually are somewhere up front, and the male may be out ahead, evidently choosing the route to be taken. Often, in getting from one bay to another, they cross the base of a forested peninsula; here they close ranks and go single file through the soft snow.

A moose upwind of the pack's line of travel is likely to be scented by the first wolves, who turn and point on rigid alert, tails out behind and noses raised in the direction of the message-bearing wind. As the lagging wolves catch up, there may be a tail-wagging greeting ceremony around the domi-

Durward L. Allen

Photographed from a research plane, an Isle Royale wolf pack at its full complement is scattered out in a long line as it crosses on the firm snow of a frozen bay.

nant pair, after which the inspired hunters bound away toward their intended prey. On a fresh scent there sometimes is a scattering of groups or individuals heading in the same general direction. More often they labor ahead, nose to tail, on a trail broken by a front-running wolf. This leader may or may not be recognizable as the dominant male.

Frequently, wolves approaching from downwind will be discovered by the moose when only a short distance away. While there is something different in every encounter, we may categorize the moose in two general classes: those that stand and those that run away. There can be vulnerable or healthy individuals in either class, although the moose that backs up against the thick spruces, lays back its ears, lowers its head, and literally invites the wolves to do their worst—to the point of charging and lashing out with its hoofs—usually will be abandoned by the pack in short order.

The other moose category that does not flee comprises those that cannot for physical reasons. A moose disabled by arthritis or with its lungs clogged by cysts of the hydatid tapeworm is doomed regardless of what it does, for the wolves easily detect its plight.

When it is strong and able to run away through deep, soft snow, a moose will not be followed very far. Struggling through such snow is an exhausting process, and the wolves soon give up. Under these conditions the wolves confine much of their travel and activity to lake ice. They frequently dig up old kills, and at these locations they may not pursue loners or even foxes with any real determination. It just seems to be too much work.

When the wolves maintain long pursuit of a moose it is nearly always under conditions where they have good footing. In 1960 there were only twelve to sixteen inches of snow on the ground. Near Wood Lake a pack of sixteen wolves scented a cow and two calves upwind at about three-quarters of a mile. The pack headed toward them, and some soon caught up. A wolf ran on each side of the three moose and easily kept up in the open. But through heavy cover, snow drifts, and blowdown, they lost ground. On a favorable stretch the pack overtook the moose and killed one of the calves in a clump of cedars.

The attack on an adult moose is nearly always from the rear, with hard, driving bites at the muscles of the upper leg. If a leg is injured, the moose can neither kick nor stand on it effectively, and further attacks are easier. They may be directed at the other hind leg, the flanks, or the anal region. With half a dozen or more wolves hanging on, the victim goes down. Sometimes a wolf will seize a moose by the nose, and one observer reported seeing a large wolf swung around through the air while maintaining such a nose grip. After a moose is disabled or down, a throat attack often brings the affair to an end.

Usually there is some evidence of leadership in the initial onslaught, evidently by a few old hands at the business, who cooperate in closing in from opposite sides. These will stay with a running moose, darting in for a gouging slash of the canines at vulnerable parts. An injured moose will turn at bay and back into heavy cover, especially thick conifers, when possible. Harried by the wolves, not allowed to lie down or browse, it will stiffen and weaken from loss of blood. Some of the pack eat bloody snow, curl up to rest, or just idle about, now and then threatening the moose, evidently to test its condition. Often enough, this is the situation when we must leave for the day, and the kill is made during the night.

It is evident that attacking a fairly vigorous moose involves some hazard, and the wolves do not always escape

without penalty. In August 1970, we retrieved the bones of a young wolf that appeared to have died the previous winter. The right scapula was splintered and adjacent ribs damaged, evidently by a blow. What kind of blow, the meager evidence does not tell us, but the kick of a moose must be suspected in such a case. When moose–wolf relationships reach the point of ultimate decision, hoofs are the moose's defensive weapon that can mean survival for yet a while. The experienced old wolves, at least, are aware that the moose can kick or strike with devastating effect.

It would be of great interest to know how many young wolves are weeded out of the population when they are inspired by a fleeing, four-legged banquet to dash in for glory and a good meal. Researcher Dave Mech has proposed—with good logic, I think—that it is the running away of the quarry that stimulates the chase. In a measure this must be true of many predators. When the prey moves out, there must be immediate action or there will not be another chance. Much of this is speculation, of course. We have little real information on why in a certain winter, in a certain pack, five pups of a litter survive until February, while in another winter there is only one or none at all, even though we saw copulation in the previous breeding season.

Many people, not too well informed, who like to idealize the beauties of nature, commonly visualize the predator as making a quick, clean kill and then eating the prey. Often this does occur, as in the case of the lioness that breaks the neck of the antelope or the cheetah that throttles its quarry by gripping the trachea in jaws too weak to do much else. In contrast, the Cape hunting dog literally tears its victim apart, although there usually are enough of them so that the process does not last long.

There would be some realism in saying that about all most meat eaters require of their prey is that it hold still. I have been impressed that prey animals caught by predators often seem to stop struggling and go into something resembling a cataleptic state, calmly submitting to being eaten until death ensues.

Although wolves can be almost uncannily sensitive to the vulnerability of their prey, sometimes they take on a moose that will not go down but is cut up to some degree by the attack. Here we must remember that infectious pathogens, so well known to our own kind, are a part of the community of life and play their part in the recycling of nutrients in the ecosystem. Even a slight wound may result in a systemic infection. A single tooth penetrating to the coelomic cavity by way of that common point of attack, the thin-walled anal area, could bring on peritonitis. Such a moose would be an easy victim for the pack on its next trip through or even for that patient social subordinate that trails the pack to take advantage of such happenings.

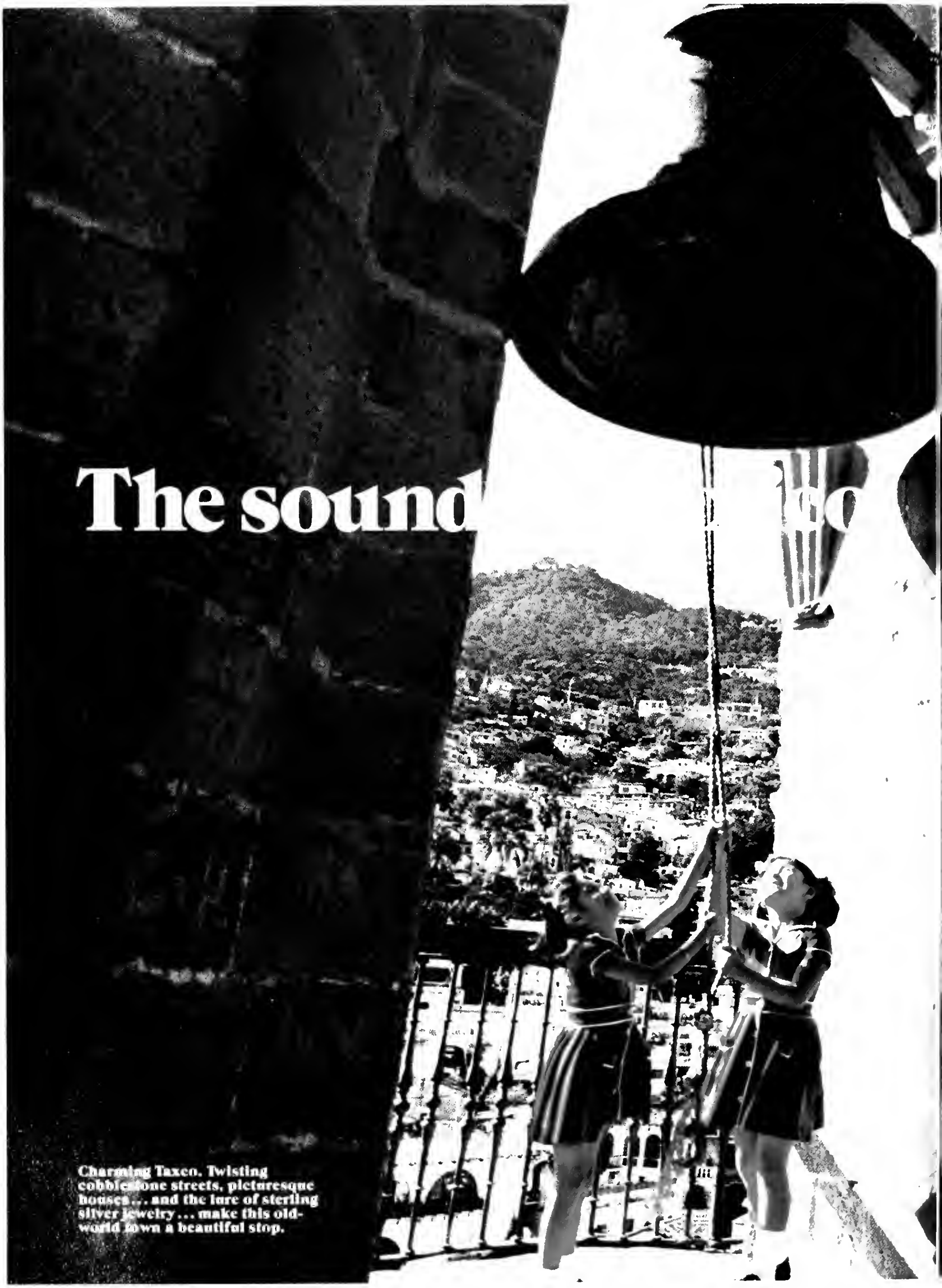
On several occasions we have recorded that an injured moose was watched by the pack for three or four days before they moved on. Then the moose disappeared and was not seen again. Possibly it recovered and survived. Or it may have wandered off to die in thick cover, not to be fed upon by wolves or other scavengers until after the snow was gone in spring. It may be one of those sets of bones represented on our autopsy cards as simply a moose mortality of given sex, age, and bone condition—if we were lucky enough to stumble upon the remains in our summer fieldwork. Getting anything like the full story on a moose mortality requires a rare degree of good timing, good flying weather, and a favorable location for landing during the winter season. It does not happen regularly.

We tend to assume that its state of health is the main determinant of a moose's fate when checked by the wolves, but other factors may be involved. One of these is how long it has been since the pack's last kill. It is not unusual for the pack to go from two to four days between kills, and after such a fast they seem to take a more responsible interest in the moose they encounter. Especially during the February mating season, their vigor fairly overflows, and woe betide the fox that bounds away over the snow before them. At other times, around a kill after the initial feast, a fox or even a snowshoe hare may move around the sleeping wolves with impunity. It is a common observation that prey animals know when the enemy is full fed and do not bother to take evasive action.

In case the distinction is not clear, wolves and other predators kill vulnerable individuals in a prey population, but this does not always mean weak or diseased animals. Whether a moose can be attacked successfully depends in part on how it takes advantage of deep snow, thick cover, the refuge of water, or other habitat conditions. On Isle Royale where the wolf mainstay is a large and long-lived prey, the carnivore must work hard for his meat. ☐

photographs by Durward L. Allen

After killing a calf in a lakeshore encounter, a pack of eight hungry wolves was held at bay by an adamant cow, which stood guard over her dead calf for more than a day. The wolves, unwilling to approach the aggressive cow, were deprived of their expected banquet and forced to return to a previous kill. After the cow had abandoned her vigil and left the area, the wolves returned to clean up their prey.



Charming Taxco. Twisting cobblestone streets, picturesque houses… and the lure of sterling silver jewelry … make this old-world town a beautiful stop.

is everywh
And it's the sound of celebration.
The bells of Santa Prisca in the historic town of Taxco have been ringing loud and clear for more than two hundred years. Summoning the townfolk to prayer. And reminding everyone when it's time to celebrate, such as on the Fiesta de Santa Prisca, when Taxco is ablaze with fireworks and pulsating with brilliantly costumed dancers.
The sound of Mexico is the sound of so many fabulous experiences. It's a turquoise wave making its way through the Acapulco night. A young boy playing a clay flute at the Pyramids of Teotihuacan. The mariachis of Guadalajara serenading you with their romantic songs.
And yes, the sound of Mexico is a reflection of friendship, too. And extraordinary value. In our cities, resorts, ancient civilizations … the sound of Mexico is everywhere. And it's unforgettable.
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Dust from the Sahara

Driven by the wind, soil particles originating in North Africa may travel thousands of miles across the Atlantic Ocean, polluting the sky over parts of Florida and South America

by Joseph M. Prospero

In a scientific journal article written in 1846, Charles Darwin recounted the following observation made while on the famous cruise of the *Beagle:*

"On the 16th of January [1833], when the Beagle was ten miles off the northwest end of St. Jago [São Tiago, Cape Verde Islands] some very fine dust was found adhering to the underside of the horizontal windvane at the masthead. . . . The wind had been for twenty-four hours previously east-northeast, and hence . . . the dust probably came from the coast of Africa. The atmosphere was so hazy that the visible horizon was only one mile distant. During our stay of three weeks . . . the atmosphere was often hazy, and very fine [reddish brown] dust was constantly falling."

Darwin was not the first to record the occurrence of dense, widespread, and persistent haze off the west coast of Africa and to attribute it to high concentrations of dust from North Africa. Mariners have noted this phenomenon in reports dating back some 2,000 years. Indeed, this region was once known to voyagers as the "dark sea" because the dense haze frequently so restricted visibility that navigation became difficult. The African coast was often obscured and certain stars used for navigation were lost in the haze that formed an artificial horizon some twenty to thirty degrees above the true horizon.

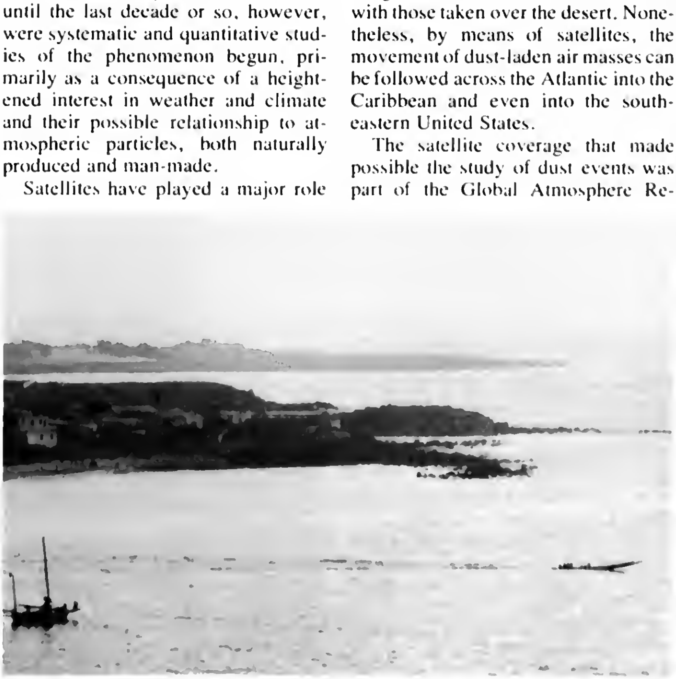
Historical accounts of haze and dust clouds attributed to material transported from North Africa are not confined to the region off western Africa. "Red" snows, caused by high concentrations of red soil particles incorporated into snowflakes, occur frequently in the Alps and the Pyrenees. These episodes usually take place during meteorological conditions indicating that the dust-laden air mass has been carried from North Africa. Likewise, dust falls that occasionally affect large portions of Europe have been traced to an African origin. Dramatic dust falls in 1901 and 1903 received widespread documentation in the press; the dust fell in such quantities that professional and amateur scientists alike obtained sufficient material for study merely by wiping or scraping exposed surfaces. A similar event in July 1969 tinted automobiles in England a pronounced reddish color overnight.

Thus, it has long been known—or strongly suspected—that North Africa is a major supplier of dust to the atmosphere and that African dust can be transported over great distances. Not until the last decade or so, however, were systematic and quantitative studies of the phenomenon begun, primarily as a consequence of a heightened interest in weather and climate and their possible relationship to atmospheric particles, both naturally produced and man-made.

Satellites have played a major role in the study of dust clouds. Satellite imagery shows that much of the dust over the tropical North Atlantic can be traced to spectacular dust storms that originate in the Sahara. These storms, which at maturity may attain a length of about 600 miles and a width of 200 miles, can be readily seen in photographs made in *infrared* wavelengths. In satellite pictures taken over the Sahara, the hot desert surface appears to be a deep black. Dust storms stand out clearly as gray-toned areas in strong contrast to the dark desert surface.

The progress of dust outbreaks across the ocean, on the other hand, is best followed by means of satellite imagery taken in the *visible* portion of the spectrum. Here again, the dust appears as a diffuse gray tone. Because conventional water clouds occur so frequently over the ocean, interpretation of these images is somewhat more difficult than with those taken over the desert. Nonetheless, by means of satellites, the movement of dust-laden air masses can be followed across the Atlantic into the Caribbean and even into the southeastern United States.

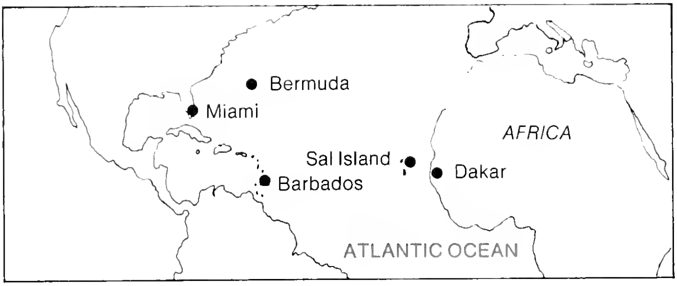
The satellite coverage that made possible the study of dust events was part of the Global Atmosphere Re-



Joseph M. Prospero

A dust storm in Niger reduces visibility to a minimum, left. Dense haze caused by such storms blurs the coastline off Dakar, Senegal, and mutes the colors of the landscape, right.

David Burnett, CONTACT



search Programs (GARP) Atlantic Tropical Experiment, commonly known by the second-generation acronym of GATE. GATE was an international effort to investigate tropical meteorological systems in order to improve our ability to predict weather. The area of investigation, the tropical North Atlantic, is especially interesting because it is in this region that disturbances emerging from Africa often develop into tropical storms and hurricanes. The GATE experiment began in mid-June 1974 and ran for three months, during which time a fleet of thirty-nine oceanographic vessels and thirteen research aircraft were deployed.

As a part of GATE, my associates and I at the University of Miami mounted a large-scale study of radiation and aerosols, the latter being a general term for particulate matter suspended in the atmosphere. We set up five land stations: at Dakar, Senegal; Sal Island in the Cape Verde Islands, 375 miles off the west coast of Africa; Barbados, West Indies, 2,500 miles west of Sal Island; Bermuda; and Miami, Florida, about 3,500 miles west of Sal Island. Instruments were also placed aboard eight ships stationed across the tropical North Atlantic between the equator and about 15°N. In addition, we made aerosol measurements aboard two research aircraft.

Daily measurements of the soil-dust concentration in the atmosphere at the surface stations showed very large day-to-day fluctuations. Off the coast of Africa, these fluctuations ranged from a factor of ten to over a hundred. On many days, the concentrations were comparable to those of a large industrialized city. These increases correlated with the movement of the leading edge of the dust clouds as observed on satellite photographs made over the ocean. By measuring the time required for the peak dust load to move from one station to the next, one can compute the transit speed of the dust outbreak. Typically, five to six days are required for dust clouds to cover the distance between Sal Island and Barbados; thus, the mean speed is about seventeen to twenty-one miles per hour.

Even as far away as Miami, about 4,000 miles west of Africa, the dominant insoluble aerosol constituent during the summer months is African dust. The presence of an air mass laden with Saharan dust is readily evident from the color of the filters used to collect the aerosol samples—they are a deep beige that is characteristic of the desert soil, many of the particles being coated with a reddish brown layer of iron oxide. In the absence of Saharan dust, the aerosol concentrations of insoluble particles in Miami's atmosphere are much lower and filters have a gray or black coloration that is primarily attributable to local pollutants. The appearance of the sky is also greatly changed in the Miami area by Saharan dust. Instead of the deep blue one expects to see in the daytime, the sky is a milky yellow gray and the sun sets as a pale yellow gray disk.

Although the concentrations of mineral aerosols in the surface-level air over the tropical North Atlantic are impressively large, the greatest concentrations occur aloft at altitudes of more than half a mile. To understand why this is so, we must first consider the meteorological conditions normally associated with the generation of dust storms.

The major dust storms observed over the Sahara during GATE generally developed late in the morning. This timing appears to be related to the development of convection associated with the strong solar heating of the surface of the African desert. Air in contact with the ground becomes heated; because of the warm air's increased buoyancy relative to the comparatively cool overlying air, the warm air rises and the cooler air sinks to the surface where it, in turn, becomes heated. As the day progresses, this mixing process extends over an increasingly deeper layer that may eventually attain an altitude of three to four miles.

High-velocity wind streams, known as jets, are often found at this altitude. When the convectively mixed warm-air layer couples with the jet stream, a vigorous interaction occurs that results in the generation of sharply increased wind speeds throughout the layer. These winds blast the desert surface with gusts of over thirty-five miles per hour, raising great clouds of dust. Because of the strong convection, the dust is mixed relatively uniformly throughout the warm-air layer.

Dust storms can be generated by other mechanisms as well. Dust outbreaks have been observed to occur in association with the passage of squall

Cattle trudge across the barren countryside of northern Ethiopia on a hunt for water. Overgrazing in the Sahel is thought to have contributed to the generation of dust.

lines and larger-scale storms and disturbances that generate high winds.

As shown in satellite photographs, the entire dust cloud moves in a general westerly direction. When it reaches the African coast, it is undercut by the trade winds. A layered structure then develops with hot, dry, dust-laden air overlying cool, moist, dust-free oceanic air. The interface between these air layers is usually located at an altitude of one-half to one mile. The temperature difference across the interface can be as much as 18°F.

This difference, known as an inversion, suppresses the convective activity necessary for the generation of the towering cumulus clouds usually associated with trade-wind systems. Instead, clouds in the region of the dust outbreaks are thin and sheetlike. This difference in cloud character is clearly evident in the visible-spectrum satellite photographs of dust outbreaks.

Despite the inversion, dust can be transferred to the lower-level cool air. Large dust particles (that is, those with diameters greater than about 20 microns, or twenty-millionths of a meter) fall at an appreciable velocity and settle through the inversion. There is also a steady erosion of the base of the dust layer, which results in a significant downward movement of material. Thus, aerosol stations on coasts, islands, and ships collect a fairly representative sample of the dust material present in the upper layer; however, the dust concentrations at these stations are considerably smaller than those in the layer itself.

Not only is there a temperature inversion at the base of the dust layer, there is also one at the top. The altitude of the second inversion corresponds to that of the top of the mixing layer over the desert, about three to four miles. Because of the second inversion, the upper surface of the dust haze has a sharply defined "tabletop" appearance when viewed from aircraft traveling above it. Flying over this vast, flat, opaque expanse, which seems to extend to infinity in all directions, is an impressive experience.

Because of the well-defined meteorological characteristics of these dust outbreaks and because of the layered structure, Toby N. Carlson, a coinvestigator from Pennsylvania State University, and I have applied the term "Saharan air layer" to them. We have shown that the Saharan air layer can be identified on the basis of its meteorological characteristics even in the Caribbean and in Florida. These characteristics are, in fact, used by meteorologists in those regions in preparing routine weather forecasts since the presence of such an air layer is associated with conditions that suppress convection (that is, produce layer-type clouds) and create haze that can often restrict horizontal visibility to a significant degree.

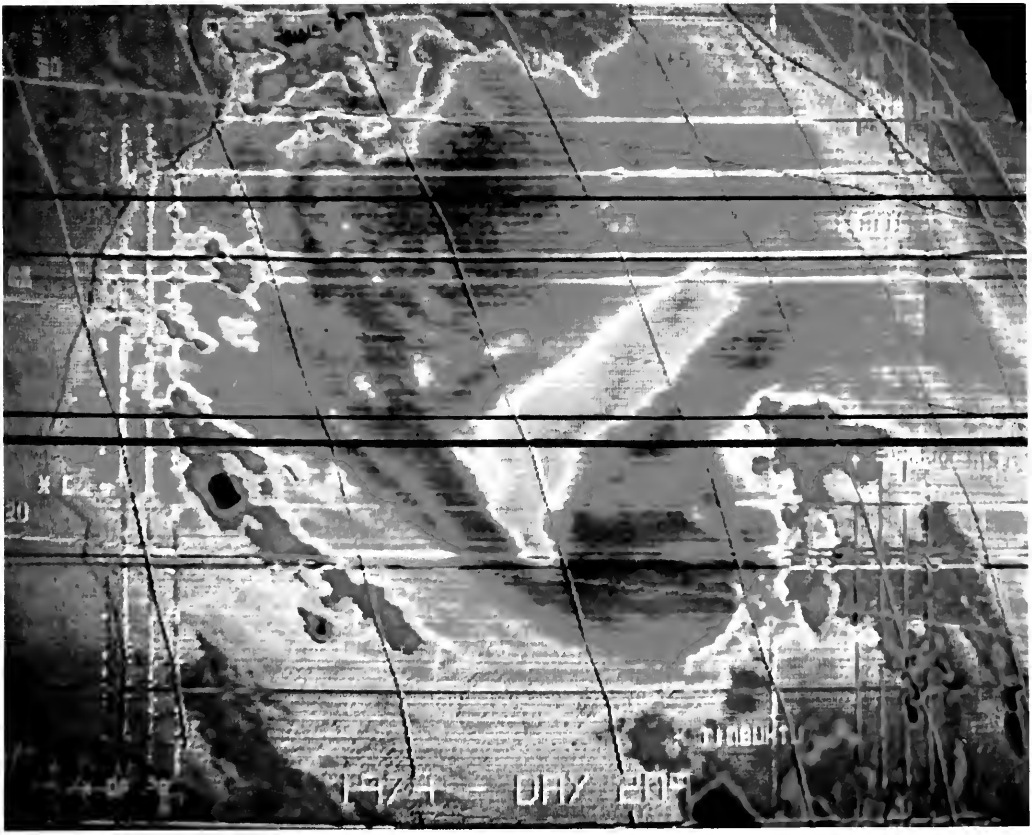
Gianni Tortoli Photo Researchers

The discussion thus far has focused on the characteristics of sporadic dust outbreaks because they are dramatic phenomena and therefore easily observed. Dust transport across the coast of Africa, however, is a relatively routine, day-to-day phenomenon. The sky is almost always markedly hazy in the eastern tropical Atlantic, even when a major dust storm has not occurred. The origin of this persistent haze is not known, but there is some evidence that much of it may be derived from the arid and semiarid region south of the Sahara. In infrared satellite photograph sequences, haze can often be seen emanating from this region. But because of the frequent occurrence of clouds, it is difficult to accumulate haze statistics for the region and to identify specific source areas by means of satellites. We can only speculate that the persistent dust haze originates from this area.

Much of the preceding material came from studies that took place primarily in the summer of 1974 during GATE. Nevertheless, there are quantitative studies on African dust transport that go back to the mid-1960s. These investigations were not carried out off the coast of Africa but, rather, on the island of Barbados in the eastern Caribbean. Ironically, the British team that initiated this work was not interested in soil dust but, rather, in cosmic dust. The scientists involved had planned to measure the day-to-day variation in the concentration of tiny, round magnetic bodies, or spherules, in the atmosphere. These cosmic spherules, as they are called, range in size from several microns to tens—sometimes hundreds—of microns; they are a common although minor constituent of deep-sea sediments. Their major component is iron with minor amounts of silicon, manganese, and nickel.

Theorists had long hypothesized that these cosmic spherules were a product of the erosion of meteoritic material that had become molten upon entering the earth's atmosphere. The British group hoped to relate variations in

Peter M Woiceshyn and R Krauss NASA-JPL



Lavender area in the center of this infrared satellite photograph, taken July 28, 1974, shows a spectacular dust storm over the Sahara. Shot when the storm was still young, the picture has been color enhanced.

the concentration of the magnetic spherules in the air to specific celestial events, such as the occurrence of meteorite showers. The major criteria for the selection of a field site for this experiment were that it be situated in a steady wind system and that the site be far removed from major land masses. Barbados seemed to be the ideal location because it is situated in a region where the northeast trade winds blow steadily all year long.

In the spring of 1965, the investigators went to Barbados and erected a 65-foot tower on the easternmost point of the island. To minimize the possibility of contamination of the air samples by corrosion products from metal, the tower was constructed entirely of wood. Once the research program was under way, however, the scientists found that their devices were collecting huge amounts of red soil dust and only minute amounts of material that might be of a cosmic origin. The quantities of soil dust were so great as to make the search for the cosmic material very difficult. Consequently, the soil dust itself became the subject of study. The group, which terminated its work in Barbados in 1966, eventually concluded that the soil material was transported from North Africa.

I established an aerosol program on Barbados in 1966, following the departure of the British group. The program on Barbados continues to this day in a considerably expanded form, and sampling goes on twenty-four hours a day throughout the year.

The long-term record of aerosol measurements compiled at Barbados shows a number of interesting trends. Among them is an annual cycle in the variation of the monthly mean dust loads. Maximum dust concentrations occur during June, July, and August; minimum values occur during the winter months. The summer maximum monthly mean value is at least ten times greater than the winter minimum mean.

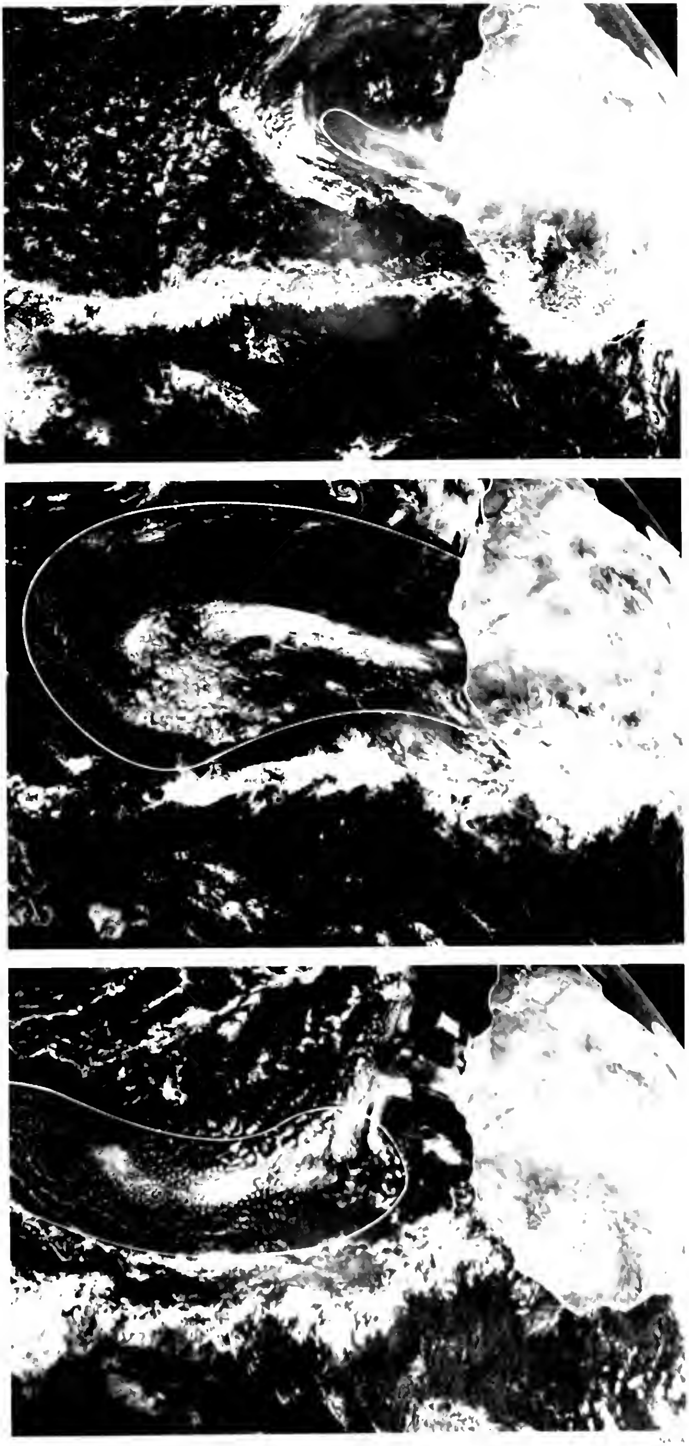
The annual cycle in the dust load at Barbados does not imply that there is a cessation of dust transport out of Africa during the winter months. Rather, the cycle appears to be a consequence of seasonal shifts in latitude of large-scale air circulation patterns over Africa and the tropical Atlantic. This seasonal shift in dust transport is most graphically depicted in changes in the frequency of haze at sea.

The meteorological definition of haze is "a suspension in the air of extremely small, dry particles invisible to the naked eye and sufficiently nu-

merous to give the air an opalescent appearance." Because haze limits visibility, marine atlases sometimes incorporate charts of seasonal haze distribution at sea. The frequency of occurrence of haze is at a maximum during the summer months along the coast of Africa between 15° and 25° N. This is the coastal region where satellite photographs show the dust clouds emerging with greatest frequency. Twenty percent of all meteorological reports from ships cite the presence of visibility-limiting haze. The path of haze occurrence extends across the Atlantic along 15° N, that is, in the same latitude band as Barbados.

With the advent of autumn, large-scale air circulation patterns over Africa shift to the south, reaching their southernmost position in winter. The haze distribution off the coast of Africa during the winter suggests that dust transport at that time is very great, the maximum frequency of haze occurrence being 25 to 30 percent. The maximum occurrence of haze in winter takes place in a coastal area that extends from 15°N southward to the Gulf of Guinea. What is most impressive about the winter haze distribution is that the western terminus of its path is the coast of South America in the region of French Guiana. Thus, if haze is indicative of dust, as evidence suggests, a considerable quantity of African dust is being transported to South America during the winter months.

The conclusion to be drawn is that the annual cycle in the trade wind dust concentration at Barbados is related to large-scale air circulation patterns. A second clear trend in the long-term record from Barbados is that the mean summer dust loads of the early 1970s were several times greater than those prior to that time. The period of increased dust loads coincided with a time of severe drought in the Sahel re-



Satellite photographs taken in the visible wavelength trace the westward movement across the Atlantic of the dust storm shown on the facing page. Two days after the storm's beginning, dense dust plumes pour out of Africa, top. Three days later, the dust is over the water, center. After nine days, the dust outbreak has moved to the western Atlantic, and the sky off the African coast is almost dust free.

gion of Africa. The Sahel, which lies south of the Sahara, approximately between latitudes 10°N and 20°N, includes portions of Mauritania, Senegal, Mali, Upper Volta, Niger, Sudan, and Ethiopia.

The drought is generally considered to have begun in 1968, even though rainfall in 1969 and 1970 was close to normal in some areas. The most severe drought occurred in 1972 and 1973, while the maximum dust concentration at Barbados occurred in 1973 and 1974. Rainfall in many areas of the Sahel returned to normal in 1974 and by 1975 alleviation of the drought was fairly extensive. Correspondingly, the dust concentration in 1975 and 1976 in Barbados was about half the peak values of 1973 and 1974. However, as of 1978, the dust concentration has remained above the pre-1970 levels.

The increase in dust aerosol concentration at Barbados does not in itself prove that an increase in dust generation had occurred in Africa. One can argue that the trend observed at Barbados is simply a consequence of large-scale changes in atmospheric circulation over the Atlantic that affected transport patterns, and thus may have placed Barbados in a denser portion of the dust "plumes" streaming out of Africa. Yet, radiation measurements made on Sal Island in 1974 by my group and by my coinvestigator Carlson show that the mean atmospheric turbidity was twice as great as that found in the mid-1960s by a researcher from the Air Force Cambridge Research Laboratory in Massachusetts. This suggests that the dust concentration off the western coast of Africa in 1974 was significantly greater than in the period before the drought.

If the aerosol increase was real, the question that logically follows is what caused this increased dust transport? It could be attributed to meteorological factors other than reduced rainfall—for example, stronger winds, increased gustiness, and altered circulation patterns over Africa. Although the question is still open to debate, there is reason to believe that the aerosol increase is probably related to the effects of reduced rainfall.

One line of evidence is based on a lag of several years between the period of maximum dust concentration at Barbados (1973–74) and the onset of the African drought (1968). This delayed response could be interpreted as the time required for the drought-stricken soils to degenerate to the point where they could be easily eroded. Certainly, one would not expect that the true desert would be affected by a drought. In the areas where major dust storms are observed, the annual mean rainfall is only a few tens of millimeters per year; there are periods when rain does not fall for years at a stretch.

In the Sahel itself, the effect of the drought on the soil was dramatic. By 1973, a desertlike state had developed over much of the region. Opinion is virtually unanimous that the present-day spread of desert conditions in Africa and elsewhere in the world is due to poor land-use practices in the arid and semiarid regions bordering the deserts. Because of population growth and economic pressures, there is a tendency to bring these marginal regions into agricultural production during periods of increased rainfall. These activities include raising and grazing livestock, plowing and cultivating new land, and intensified wood collection around new camps and settlements. This appears to be the case in the Sahel, where there was an extended period of abnormally high rainfall during the 1950s and normal rainfall during the early 1960s. Over this twenty-year period, the way of life in this region changed radically, as did local land-use practices.

Raising livestock is probably the only one of these activities carried out on a sufficiently large scale to affect the soil so adversely as to significantly increase the generation of dust. In the Sahel, only 2 percent of the total land area was being cultivated in the mid-1960s. In contrast, 20 percent of the land area was used for grazing. The effects of overgrazing on ground cover and soil stability are dramatic. The destruction of the soil surface is most evident in the vicinity of wells, where the countryside is often stripped bare and pounded to dust over a ten- to fifteen-mile radius from the wellhead. These barren areas are clearly visible in satellite photographs.

The impact of land-use practices on the rate at which soil is eroded and lifted by wind is not a newly discovered phenomenon. The 1930s "dust bowl" in the United States is a typical example on a grand scale of the catastrophic effects of poor agricultural practices compounded by an adverse fluctuation in the climate. Even under normal conditions, the lifting of soil by wind accounts for a substantial percentage of total soil erosion in the United States—one billion tons per year by wind as compared with four billion tons by water. In fact, the occurrence of widespread and spectacular wind erosion in the United States has become more frequent in recent years because of the increased incidence of drought and an apparent decrease in costly soil conservation measures. In this regard, one might note that locations in the United States that consistently exceed the primary national air-quality standard for total

Severe drought in the Sahel in the early 1970s wiped out many herds of cattle and increased the usual dust load originating in the area.

suspended particulate matter are predominantly rural agricultural areas, not urban ones. The same problem of wind erosion exists in the Soviet Union where the frequency of dust storms in certain areas has increased markedly since 1950 as a consequence of the agricultural development of so-called virgin lands.

Studies of Saharan dust have given us a better understanding of the relationship between weather, climate, and the transport of soil aerosols over great distances. They have also given us an indication that land-use practices, in combination with the variables of weather and climate, may be responsible to some degree for the increase in dust storms. While the generation and transport of soil aerosols is affected by climate, the soil aerosols can themselves affect climate in a number of important ways.

Large concentrations of soil aerosols can alter the radiative balance of the atmosphere, resulting in either a net warming or net cooling of the earth-atmosphere system. The direction is dependent on such factors as the physical and optical properties of the aerosols, their altitude distribution, and the radiative character of the underlying surface of the earth. Soil aerosols can also affect the microphysical processes by which clouds are formed and, hence, the character of the clouds. Any process that affects clouds can, in turn, affect climate. This is because clouds may have an impact on precipitation in addition to playing an important role in determining the radiative balances of the earth.

If dust can affect climate, then knowledge about the sources of dust becomes important. Clearly, the Sahara is a major source. But arid regions and deserts abound on the earth—20 percent of the global land surface is classified as arid or desert. There is evidence for the occurrence of large-scale dust transport in many of these areas—the Arabian Peninsula, the Middle East, the southern Soviet Union, Central Asia, Australia, southern South America, and the western United States. At present, our knowledge about the impact on the atmosphere of dust from these regions is limited. Over the next decade, however, programs already under way should give us a much better understanding of the importance of these sources of natural pollutants. □

Clyde H. Smith, Peter Arnold

Fire Blight

Not as pleasing as partridges in pear trees, fire blight bacteria blacken and kill North American pear orchards and are threatening those in Europe

by Robert N. Campbell

In the spring, pear trees in bloom are a pretty sight in California and the Northwest states. But the blossoms provoke the unhappy thought that in the fall, there will be, as usual, fewer pears than apples in the markets. Last year, this country produced 3.69 million tons of apples, while the pear crop fell to 0.69 million tons.

Now, the pear grower may be discouraged by consumer preference for the durable, storable apple over the pear, whose thin skin bruises easily, and whose grainy texture quickly turns to mush. But fragility is not the main reason why Americans consume few pears. The real culprit is a bacterial infection called fire blight, so named because when it strikes a pear tree, the blossoms, young fruit, and shoots wither and blacken as if they had been burned.

When pre-Revolutionary colonists

This pear tree, growing wild in Vermont, is a descendant of trees brought to New England by colonists. Because it stands alone in a field, the tree has escaped fire blight, which spreads quickly in orchards.

Steven V Beer

Below left: In early spring, just before the blossoming season, a reddish brown exudate, containing millions of cells of the bacterium Erwinia amylovora, *oozes from a holdover fire blight canker on a Bartlett pear tree in upstate New York. Below: Fire blight infection occurs during flowering, and by late spring, the blossoms and leaves of this California pear tree have withered. Left: In this small branch of an apple tree in upstate New York, the fire blight infection will probably result in the formation of holdover cankers, which will release the pathogen the following season.*

Steven V Beer

Sherman V Thomson

brought apples, pears, and quinces to North America, little did they realize that the fire blight bacterium—unknown in Europe—existed in the new land or that it would find their plants so attractive. In North America, the fire blight bacterium had evolved on indigenous rosaceous host plants such as hawthorn (*Crataegus* spp.), mountain ash (*Sorbus* spp.), service berries (*Amelanchier* spp.), and North American species of apple (*Malus* spp.). During a long course of coevolution, the disease-causing bacterium and its host plants had arrived, more or less, at a balance. The host plants developed enough resistance so that they seldom succumbed to the bacteria, yet the bacteria never passed out of existence.

The amount of disease in any year depended on whether the weather favored or inhibited bacterial infection. If the weather was unfavorable, hosts could, and can, limit the extent of fire blight invasion, even in the face of numerous infections, and develop normally the next year. Outside my office building there is a small hawthorn tree; in most years I can find a few blighted twigs on it. In 1976, however, rain, warm air temperature, host development, and insect activity coincided to favor the bacteria, which then infected and killed nearly every blossom and invaded the small twigs on which the blossoms grew. By late summer, the tree looked completely brown from the mantle of dead leaves on the infected twigs, but on close inspection I saw that only the small twigs had been invaded and bacteria had not progressed into the larger branches or stems. In 1977, the tree leafed out normally, and since environmental conditions did not favor the bacterium, there were only the usual few infections.

When they were first introduced in North America, apples, pears, and quinces probably grew free of fire blight for many years. Early cultural practices might have helped prevent disease. The first trees to arrive in North America were most likely seedlings that varied in susceptibility. Probably grown as single trees in sod, they were given a minimum of attention and fertilization. Growers have long since found that trees so cultivated grow more slowly, develop greater resistance, and are less susceptible to fire blight than lush, rapidly growing trees. As they were planted more widely and European cultivars introduced, the

trees were grown near infected native plants. The bacterium then simply spread from the native hosts to nearby pears and apples. This happened, at least in New York's Hudson River Valley, before 1780, the earliest record of extensive blight.

Although the severity of attack varied from year to year, depending upon the weather, the blight continued to spread throughout the eastern states. As nineteenth-century farmers observed their decimated crops, they gradually gave up the culture of the most susceptible plants in areas plagued with frequent blight epidemics. By about 1900 in the eastern United States, the contemporary distribution of pears and apples had been established. Growers had largely discontinued the European pear as a commercial orchard tree except in small areas of Michigan and New York, where cool weather discourages blight. Elsewhere today, there is only small-scale cultivation of lower quality, blight-resistant pears. Because apples generally are more resistant to fire blight, growers continue to cultivate apples on a large scale, using a combination of the more resistant cultivars and control measures for fire blight.

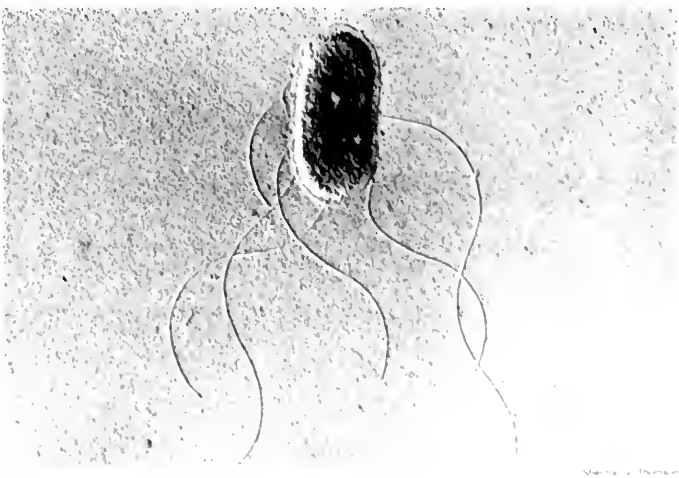
In the western United States, settlers continued to raise pears during the nineteenth century, convinced that the arid climate would prevent blight. But in 1887, fire blight was found in California, and from 1900 to 1910 epidemics occurred in all the western states. In severely blighted areas, such as the San Joaquin Valley, 95 percent of the trees were lost in four years. There, as in the eastern states, the pear industry failed and has never been reestablished. Considering the explosive potential of the bacterium, any commercial production of pears in North America is surprising. Today most of the pear industry is located in the western states. In most growing seasons, western spring weather does not favor fire blight and summers are too dry for new infections; consequently, attempts to control the disease have had moderate success in western orchards.

The symptoms seen by early American farmers are the same seen today on pears, apples, and other susceptible plants. In the spring, the trees begin to grow normally. Suddenly, especially after a rain, blossoms may wither and turn black. This is the blossom-blight phase, which quickly develops into spur blight as bacteria invade the flowering spurs, and the leaves on the spur rapidly wither and die. Flowers and leaves soon turn black as if scorched. As infections continue to advance and bacteria kill plant tissue, young shoots wilt and die, and larger limbs, the trunk, and even roots may develop elongated dead areas called cankers. Once suckers from the rootstocks are infected, the bacteria can also quickly spread to the roots. In rainy climates, additional infections can begin during the summer, when bacteria infect the leaves, shoots, or green fruit.

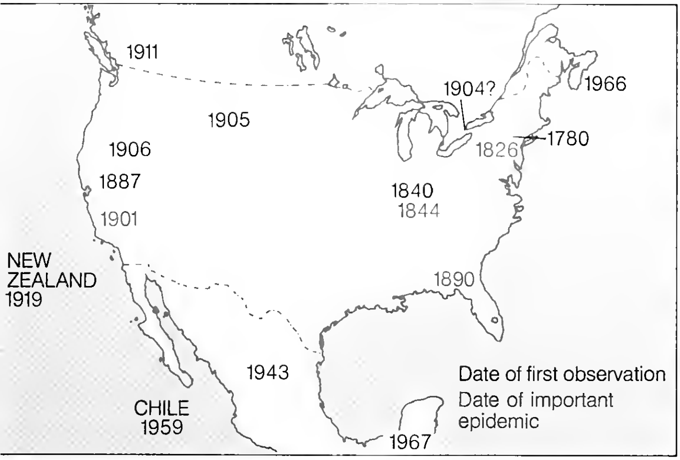
The fire blight bacterium is only able to infect plants of the Rosaceae family, but susceptible plants include more than one hundred species. Some rosaceous plants, such as peaches and roses, resist infection; others, such as hawthorn, can be infected but restrict the bacteria to flower spurs or young shoots. Pears and apples have less resistance, however. A pear tree is more likely to have infections that spread faster and farther into the trunk than an apple tree.

Before it can be controlled, the nature and cause of a disease must be understood. When fire blight was still ravaging pears and apples in the eastern United States, epidemics were blamed on lightning, freezing of sap, rays of the sun that were either reflected or concentrated by vapor in the atmosphere, insects boring in the branches, or enfeeblement due to cultivation. Such theories were common explanations of plant and animal diseases before the germ theory was proved and widely accepted. In the late nineteenth century—only a few years after Pasteur had demonstrated that microbes do not appear spontaneously in putrefying food but are generated by other microbes, and Robert Koch had shown that a specific bacterium caused anthrax in sheep—T.J. Burrill and J.C. Arthur proved that the real cause of fire blight was a microscopic bacterium, now called *Erwinia amylovora*. Burrill and Arthur actually provided the first proof that bacteria caused plant diseases. In 1891, another worker, M.B. Waite, clearly defined the role of the honeybee in transmitting fire blight bacteria from blossom to blossom.

From the bacterial point of view, life is hard and dangerous. Fire blight bacteria must survive the winter, or dormant season. Like most bacteria that cause plant diseases, the fire blight bacterium is not hardy and dies quickly if exposed to the elements in winter. The bacterium avoids the problem by staying inside the host plant. In some trunk or branch infections, bacteria remain alive over the winter in what are called holdover cankers. In the spring, as the trees begin to grow again and air temperature rises, bacteria become active and multiply in such numbers that they ooze out to the surface of holdover cankers. Once on the surface of the bark, bacteria cannot fly, jump, or



This transmission electron micrograph shows the bacterium Erwinia amylovora *magnified 30,000 times. The long, whiplike flagella are the bacterium's means of locomotion.*



In 1914, apparently a year that favored fire blight, infected trees in this seven-year-old Colorado orchard were cut back. They had been the same size as the trees in the background.

make any movement except swim for microscopic distances. But they can be carried by anything that moves in the orchard. The most important agents are those that provide movement from holdover cankers to blossoms, for example, mites, insects such as flies and ants, and splashing water drops blown by wind.

Researchers have always assumed that when bacteria reached the blossoms they multiplied in the nectar and then infected the flower through the nectaries or were transmitted to other blossoms by honeybees or by rain. Recently, highly selective culture media have been developed, permitting researchers to quickly distinguish fire blight bacteria from harmless bacteria, yeasts, and fungi that also occur on leaves, twigs, and blossoms. Surprisingly, they have found that the stigmas of pear flowers seem to be sites where bacteria begin to multiply and from whence they are splashed or carried to the other parts of the blossom—or to other blossoms where infection may set in. In many years, bacteria are present in large numbers in blossoms for about two weeks before they actually infect the blossom tissues.

The number of blossoms infected is very small compared with the number containing the bacteria, and there is a minimum threshold air temperature for infection. In the west, blossoms that open when the daily mean temperature is less than a gradient drawn between 62°F in early March and 58° in early May are not likely to be infected. Obviously, there is a great deal of interaction, probably at the biochemical level, which accounts for the success or failure of infection. A better understanding of this interaction and the effects of temperature might enable researchers to improve resistance to infection through the breeding of more resistant pear varieties. In the eastern United States, researchers have used the special culture medium but have not observed the two-week lag between the population explosion of the bacterium and infection.

Although blossoms are the most susceptible parts of the tree and usually the first to be infected, bacteria can infect other parts as long as there are stomata or wounds and as long as a film of moisture from dew or rain is present to permit bacteria to swim into the openings. In the eastern states, new infections of leaves, young shoots, or fruit occur during the summer as a result of heavy rain, wounds caused by hail, or punctures left by feeding insects. In the drier western states, where the pear industry now is concentrated, summer rarely heralds such incidents.

Regardless of where the infection starts, the bacteria multiply and advance through the inner bark of the tree from shoots to limbs, trunk, and roots, killing host tissues en route. Within the host, the bacteria remain well protected from drying, exposure to sunshine, or chemicals sprayed on the bark. As autumn approaches, the trees become dormant, and bacteria exposed on the surface of the host and in small twigs or spurs quickly die. The bacteria in some of the larger branches become dormant in the holdover cankers, awaiting another spring and their new seasonal cycle.

Using knowledge of this cycle, plant pathologists and growers have tested and modifed control methods and now combine biological and chemical procedures. When growers prune pears in the dormant season, they particularly try to detect and cut off holdover cankers. These are not always easy to see, and they may extend farther into the bark than is apparent on the surface. During flowering, when they are

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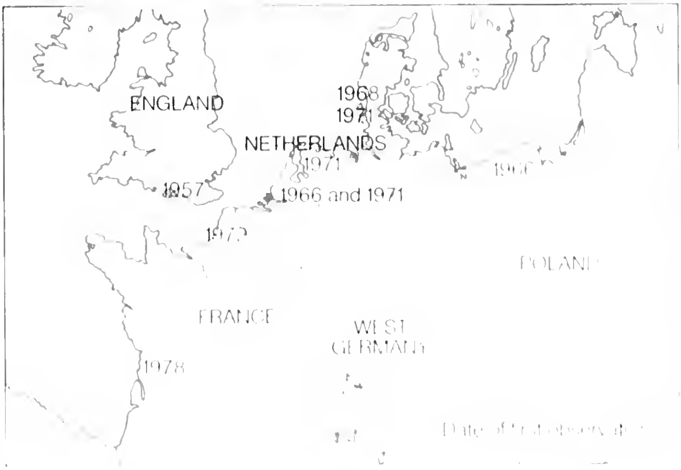
most vulnerable to infection, trees are sprayed with a bactericidal chemical, either streptomycin (an antibiotic) or a chemical that contains copper. There are problems with both types of sprays: fire blight bacteria can become resistant to the antibiotic, and the copper may cause russeting, an unsightly but harmless blemish on the skin of the pear. These sprays are designed to keep enough chemical on the flowers to prevent bacterial multiplication and infection. Unfortunately, California's mild climate prolongs the blooming period of pears from March to May, necessitating as many as twenty sprays at five-day intervals. Using the minimum threshold temperature to predict the risk of blight, growers have been able to omit early sprays in some seasons and to control blossom infection



with fewer, well-timed sprays. Finally, during the spring and summer, growers patrol orchards and promptly prune out new infections that occur in spite of these control measures. In a bad blight year, a drastic number of branches may be cut off.

Besides this yearly battle with fire blight, scientists and orchard growers have enlisted host resistance as part of their long-range strategy. The common pear, *Pyrus communis*, originated in Europe and has many variable characteristics, such as leaf shape, presence of thorns, fruit shape, and fruit quality. Pear trees cross-pollinate so that the genes governing these characteristics are shuffled in each crop of seeds. Prehistoric Europeans discovered that some trees had better fruit than others and began to propagate these trees, indefinitely maintaining a choice selection of genes by grafting.

Greek and Roman records mention different types of pears that probably would not be relished by modern consumers. The great development of today's wide range of pears began in the seventeenth century in France and Belgium. Pear breeders—or natural cross-pollination—made crosses; the hybrid seedlings were tested and the best were propagated and sold. Thousands of named cultivars were produced and exported to North America, where they were exposed for the first time to the fire blight bacterium. In general, all these cultivars were and are very susceptible to fire blight, but a few, such as Seckel, have enough resistance to be grown in the eastern and southeastern states. Unfortunately, the fruit quality does not match that of such cultivars as Bartlett, Anjou, Comice, or Bosc. Of these, Bartlett is the most important because of its wide adaptability and its suitability for fresh eating, canning, or drying. Bartlett remains an important cultivar in Europe, where it is known by its original name, Williams or Williams Bon Chrétien.

Several species of *Pyrus* have been introduced to North America from the Orient. One, *P. pyrifolia*, was introduced in eastern states and found to be resistant to fire blight. Fortuitously, *P. communis* and *P. pyrifolia* could be crossed, so that blight-resistant hybrid seedlings could be produced either naturally or in breeding programs, resulting in the cultivar Kieffer, which Peter Kieffer picked up as a chance seedling in Philadelphia in 1863, and in bred cultivars such as Baldwin, Orient, Hoskins, or Morgan. Although they are resistant to fire blight and can be grown in eastern and southern states, these hybrids do not have high-quality fruit, partly because they inherit some fruit characters from *P. pyrifolia*, whose common name, sand pear, reflects the fruit's grainy texture. Of the cultivar Kieffer, U.P. Hedrick wrote in *Pears of New York* (1921): "Its popularity can be accounted for only by accepting Barnum's dictum that 'Americans love to be fooled.' Pears are grown to eat, but those of Kieffer are fit to eat only in culinary preparations, dire necessity alone compelling their consumption uncooked."

In addition to *P. pyrifolia*, other oriental species, such as *P. ussuriensis*, *P. calleryana*, and some individuals of *P. betulaefolia*, have been found to be resistant to fire blight. These species cannot be crossed with the common pear, but during World War I, their fire blight resistance was adapted to pear culture in another manner. Since choice cultivars of pear are maintained by vegetative propagation, seedlings from wild or even cultivated *P. communis* were used as rootstocks. A desirable cultivar grafted onto the seedling yielded a composite tree. Unfortunately, these rootstocks were susceptible to fire blight and became infected as the bacteria either advanced down the trunk or infected suckers from the rootstock. The results were rapid loss of the entire tree and a holdover canker that was almost impossible to find.

Various other types of composite trees were therefore grafted together. The ultimate tree had blight-resistant roots derived from oriental pear seedlings, a blight-resistant trunk and framework from Old Home (a blight-resistant selection of common pear with a less desirable fruit), and blight-susceptible branches that produced quality fruit. When blight struck and branch infection occurred, bacteria did not advance into the resistant framework. An infected branch could be pruned out without losing the entire tree. This practice led to problems, however, as these trees were widely planted over areas with different soils and climates. The fruit often developed black end, a blemishing condition that made it worthless.

In the 1960s another disease, pear decline, spread across the western pear orchards, particularly devastating trees with some of the oriental rootstocks. Leaves and fruit quickly wilted and dropped off, and within a few weeks the trees were dead. Pear decline put a speedy end to pears growing on *P. pyrifolia* and *P. ussuriensis* rootstocks. From 1959 to 1972, about two million pear trees were lost to this disease in California alone. Composite pear trees are now made with *P. communis* seedlings for roots, a blight-resistant trunk stock, and the desired cultivar added for the branches. With the advent of better blight control through blossom-time spraying, the need for blight-resistant rootstocks has diminished.

One benefit of this blight resistance program was the introduction of valuable ornamental pears such as the Bradford selection of *P. calleryana* used as a street or landscaping tree. This variety is highly resistant to fire blight, has a beautiful display of flowers in the spring, red foliage in the fall, and small fruits that do not make a mess on sidewalks or lawns.

In North America, its native home, fire blight undoubtedly deserves blame for limited pear production and, therefore, some blame for the lack of a domestic pear brandy. Thanks to its ability to travel with people across plains, mountains, and oceans, fire blight can cause trouble anywhere. The disease appeared in New Zealand as early as 1919, but has incited greater consternation in Europe, the ancestral home of *P. communis*. Fire blight was discovered in England in 1956 and subsequently on the continent. Vigorous attempts are being made to control the disease. The Dutch and the Poles eradicated infection sites discovered in 1966, but attempts to eradicate the 1971 infections in the Netherlands and the 1972 infections in northern France have not succeeded.

The fire blight bacterium has established itself along the northern edge of the European continent but the region's generally cool weather only marginally encourages fire blight epidemics. Throughout Europe, however, there are few natural barriers to the bacterium, and a relatively continuous distribution of hosts—commercial pear orchards, susceptible ornamental shrubs such as cotoneaster, and hedgerows of hawthorn. In 1978, the disease was found to have spread south to three orchards in the Bordeaux area of France, where the weather is warmer. If the American experience is any guide, the outlook is grim indeed for pears in France, Switzerland, Germany, and Italy. Chances are there will be fewer pears in Europe—and they will cost more. □

This engraving of a Lady Petre pear is from The American Pomologist, *published in 1851. In 1735, Lady Petre sent seeds of this variety from London to the colonial naturalist John Bartram.*

Charles P. Mills, Pennsylvania Horticultural Society, Philadelphia

A Subterranean Snake with a Funny Tail

Having a tail that looks like a cut salami can be an advantage if you are followed into your hole

Text and photographs by Carl Gans

The granitic mountain ridges of India and Sri Lanka were once heavily forested. Millenniums of weathering and organic activity had covered them with soil that supported a complex vegetation rising well over a hundred feet into the air. Most of the trees are now gone, cut for lumber and to make room for tea and cardamom plantations. Much of the soil has also gone, washed from the hills by monsoon rains or blown away by wind.

Although odd patches of trees remain, much of the original fauna is gone. Lack of cover has exposed large species to decimation by hunters, and altered habitat and climatic conditions have devastated populations of large and small animals alike. Yet some species have survived the changes, and a few are probably more common than ever. For some animals, their altered circumstances are probably similar to those they were originally adapted to and their needs for survival are being adequately met; for others, the removal of a predator or the provision of a new food source has opened fresh opportunities.

The uropeltids, a group of some forty, highly specialized snakes distributed throughout the montane regions of southwestern India and across most of the island of Sri Lanka, include species that have suffered from the removal of mountain forests and others that have increased their ranges. These subterranean snakes sport shiny black scales with bright orange, red, green, and bluish markings and show a strong iridescence when viewed in sunlight. They are called "shieldtails" because in most species the tip of the short tail

The blunt, scaly tail of a uropeltid, or shieldtail, serves as a defense mechanism. Soil, adhering to the scales, creates a plug, which foils other, predatory snakes that follow the shieldtail down its burrow.

is roughened and formed like a spiny plate. In contrast, the head is always pointed and formed into an elongate cone. Upon first observing a shieldtail, one tends to mistake tail for head, and this confusion is further increased by the snake's habit, when dug up, of curling around twigs and clods of earth in its attempt to hide its narrow head and display its blunt tail.

Records from the last century indicate that these snakes were found at various elevations in the moist forests of the Western Ghats of India and the mountain ridges of central Sri Lanka. Many species are now extremely common in agricultural areas; others are far less so, being restricted to isolated hillsides or found deep in the soil of tropical lowlands. With some exceptions, shieldtails show modifications for a single, specialized biotope, the rain forest. Their survival in different habitats may be explained by considering how the animals are structurally and behaviorally adapted to certain sets of environments.

When burrowing from the surface or extending tunnels underground, a shieldtail drives its cone-shaped head into the ground, forming a short tunnel. The snake curves the anterior part of its backbone, forcing its sides against the wall of the tunnel in the same way that a mountain climber pushes his legs against the sides of a rock chimney, using this as a base from which to lever upward. As soon as the head has been driven into the tunnel's end, the backbone bends anew and forms a new S, pushing the skin into renewed contact with the walls of the tunnel. The pressure exerted is sufficient to widen the tunnel until it becomes more than twice as wide as the back of the head.

To effect this curvature, the snake's skin separates from the underlying portions of its body, allowing it to slip freely along the outside. Consequently, the curvature occurs within this envelope, and all one sees superficially is that the neck and anterior part of the body suddenly become wider just after the head has been driven into the soil. Curiously enough, the animal does not use its tail to provide resistance for the push; indeed, crawling shieldtails seem to drag the posterior part of their body passively.

The nature of the burrowing pattern is clear. The conical head, driven by muscles that control the neck (two sets, benders and straighteners), provides a wedge that forms the beginnings of a tunnel. Each time these muscles fold the neck into an S-shaped curve, the tunnel is widened. As the curvature of the backbone involves slippage within the skin, the widening proceeds smoothly, resulting in a tunnel wider than the body diameter. This method of propulsion and tunnel formation has advantages—it allows the animal to concentrate the propulsive machinery in that portion of the body anterior to the heart. Here the bones are much heavier and most of the cross section of the trunk is occupied by muscles. The alimentary canal and tracheal air passage to the lungs are very narrow. This pattern changes completely just before the heart. Posteriorly, the bones become more slender and only some 15 percent of the body's cross section is taken up by supporting and propulsive machinery. The body cavity holds the stomach and liver and, in females, the developing embryos.

Even the muscles are serially modified. The anterior ones are red with myoglobin, whereas the posterior muscles are white. The anterior muscles are also richer in variety and quantity of enzymes. All this provides energy for rapid and sustained contraction. The animal's propulsive front end thus drags the visceral tube through the ground, the way a locomotive drags a freight train. The "locomotive" method of movement has another advantage that involves aspects of reproduction. Most of these snakes are live bearing, and sharp bends by the posterior part of the body of female snakes would presumably impose undesirable pressure on the developing young.

Shieldtails almost always have to be excavated by collectors. While a few specimens have been observed on the surface, this is generally under unusual conditions. Freshly captured specimens often regurgitate earthworms, apparently captured in the tunnels or in surface litter. (One large species also takes insect grubs.) The shieldtails' smooth, conical teeth grip the slippery prey and keep it from tearing while it is being swallowed. Some tunnel networks show multiple horizontal passages and a few very deep ones. Larger specimens may make deeper tunnels and often have systems that pass among roots or beneath boulders.

Even though it fits rather loosely within the tunnel, the shieldtail body is subject to abrasion from the continual contact with soil particles. This is particularly true for those species that live in sandy soils. A second problem is friction between the body and its surroundings. Friction is useful when the animal pushes against the tunnel walls, providing a base for extension of the tunnel. It is disadvantageous or makes for extra work when the body is dragged through the tunnel. Even more critical is that the skin must also be smooth enough so that various kinds of mud will not adhere to it or dry on its surface. The friction would then be between soil and soil, rather than between skin and soil.

The shieldtail body is covered with smooth, flexible, rounded scales, with free edges that overlap like shingles and limit the entry of particles. Much of this flexible edge is replaced every time the snake sheds its skin, so that minor damage to the most sensitive areas is automatically repaired. This outside surface and the free edges are composed of a special, horny substance, known as β-keratin, that has high wear resistance and is difficult to penetrate. In contrast, the protected skin of the hinges between the scales is formed of the more flexible α-keratin. A few specialized parasitic mites make use of this difference; with their flattened bodies, they are able to move about beneath the scales. They walk upside down and suck the snake's blood through the α-keratin-covered "soft underbelly" of each scale.

The surface of β-keratin is not laid down randomly. Rather, it is formed as an array of ridges parallel to the long axis of the snake and spaced about 2,500 angstroms apart. These ridges are cross-connected by small, intermediate bridges near the bases of the grooves. The ridge spacing provides a diffraction grating, producing the iridescent physical colors that pass in lines curving lengthwise along the body, ranging from orange near the midline to blue near each side. The color is irrelevant to the animal, the role of the spacing is quite clearly to generate a regular surface that mechanically limits the attachment of soil particles. The spacing (and iridescence) appears to be quite similar in different

When unearthed, a shieldtail will coil its body and begin digging into the soil. This behavior may have evolved as a defense against the "peck-flips" of jungle fowl, probably a major predator of shieldtails.

kinds of subterranean snakes and around the circumference of any one species. When disease prevents snakes from shedding regularly or when lesions, due to infection or other causes, break up the array, the eroded spots allow soil to adhere to the surface.

Another set of adaptations reflects the snake's defense against predation. Two separate systems are apparent, one directed at predators encountered in burrows and the other at those encountered at or near the surface. Perhaps the most interesting specialization is that against burrowing predators, presumably some of the small snakes such as pipe snakes and venomous kraits, which can burrow for short distances or at least travel along existing tunnels. Such snakes, tracking their prey down a burrow, will encounter shieldtails either head first or tail first. In the former case, the shieldtail has no defense, and stomach contents show that pipe snakes generally had swallowed shieldtails head first.

Most shieldtails have an elegant tail defense mechanism for use in tunnels. Unlike that of most other snakes, the uropeltid tail tends to be blunt; in a few species it may appear as distinct as the diagonally cut end of a salami. The scales covering the terminal end show a completely different surface structure from those shielding the body. At the sharp transition between the two regions, the surface loses the smoothly aligned ridges and becomes rough. Various sharp points project outward, and ridges upon these lie at angles to each other rather than parallel. Consequently, soil and sand tend to catch here to form a thin layer of dirt particles. Other soil particles can then adhere to this surface, and uropeltids generally show, attached to the tail, a clump of dirt that blocks their tunnel. Since many predatory snakes can negotiate a tunnel but may have trouble burrowing, this method of foiling the potential predator affords effective protection; it should also limit the attention of centipedes and other predatory invertebrates that might otherwise attempt to nibble on an unprotected tail.

A second set of specializations deals with predators that hunt on the surface. Most snakes have a fairly blunt head and a slender tail. Uropeltids reverse this pattern and further enhance the contrast by a yellow band around the tail and markings on the posterior surface that may suggest eyespots. Similarly, slender and converging lines on the head give the impression that the anterior end is slimmer than it actually is. Apparently, there is an advantage to fooling sight-hunting predators into attacking the shielded, mud-covered tail rather than the vulnerable head. Some shieldtails show a dorsal color close to that of the soil they inhabit. Humus-dwelling forms are dark; other forms are yellowish or reddish. This, again, is likely to be advantageous in avoiding the attention of a sight-hunting predator.

Furthermore, most shieldtails show lateral banding of one kind or another, particularly along the front and rear of the body. These bands do not pass across the dorsal surface. Such interrupted red markings are also characteristic of various species of large and venomous centipedes that occur in the same environment, leading to the suggestion that the snakes may be mimicking them. The mimicry may also be advantageous in deterring a predator that hunts by sight. When a shieldtail is unearthed, its behavior enhances this aspect of its coloration. It tends to move relatively little. Instead it curls itself around any handy object, such as roots or grass tussocks. Characteristic of the coiling is that the head is generally at the center and often starts a digging movement while the tail is prominently projected or extended. The tail may even wave about when the animal is touched.

The question, To which predator is this behavior addressed? suggests the first set of clues to establish the shieldtails' former habitat. The predator involved must have lived on the surface and been capable of digging up the first few inches of ground, and shieldtails must have encountered it with reasonable frequency. It must have had good vision, preferably color vision, a requirement that eliminates most small mammals. The obvious predators would be medium-sized birds of the forest, specifically jungle fowl, a group from which domesticated chickens are supposedly derived. These omnivorous birds find some of their food by scratching up the surface of the ground. They not only dislodge the leaf litter, but actually penetrate the soil. But were they common enough to be a major predator of shieldtails? The literature of the last century suggests that indeed they were and, coincidentally, indicates why they are now scarce. It talks of evenings spent in resthouses where the inhabitants were disturbed by the scratching and calling of jungle fowl from all directions. There is also mention of shooting bags of hundreds of birds in a single day and of thousands of birds that appeared when bamboo or other mast fruiting trees offered a windfall. Apparently, these gallinaceous birds were common enough to have posed a threat to shieldtails and to have evoked their defensive system, which involves color matching, centipede and head mimicry, and coiling behavior.

Experiments with captive jungle fowl in the Colombo zoo show how the shieldtail defense works. When attacking worms and insects, the birds peck them one or a few times before swallowing them. But when attacking small snakes, they treat these entirely differently. They give brief pecks at the head or tail of the potential prey, biting down and, in the process, lifting and flipping. Such peck-flips are repeated dozens or even hundreds of times until the prey stops moving, a process that takes twenty or more minutes in the case of a shieldtail. The birds generally mistake tail for head and, in a series of trials, peck at the tail about ten times as often. Such pecks leave the snake apparently undamaged and it is only when the head or midbody is hit a few times that the peck-flip produces obvious damage. What is more important is that a snake coiling itself about roots or clods of earth as it is scratched up is difficult to flip. The tail distracts the bird's attention, but the head keeps on digging, so that less and less of the body is exposed to successive pecks. Even if the bird grabs and pulls, it will have great difficulty dislodging a snake that has more than half its body buried.

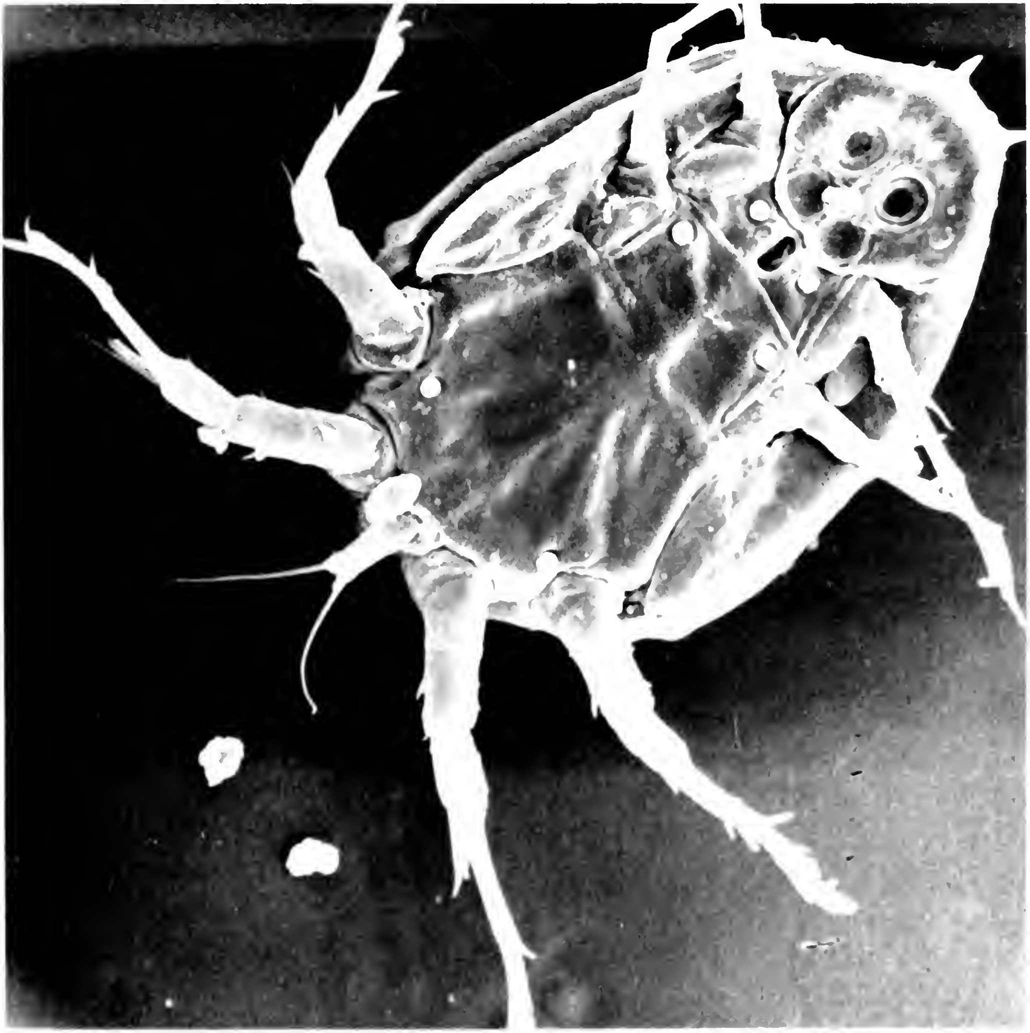
The assumption that the shieldtails were once primarily forest animals matches their fairly low preferred temperatures of about 75°F, which might otherwise be unusual for animals existing close to the equator. Whether they originally lived in lowland or in montane regions is not clear, however. Certainly the Indian species are overwhelmingly inhabitants of the mountains; only one of some thirty species has been taken in low country. In Sri Lanka, of some ten species of shieldtails, at least four occupy lowland regions. The lowland forms are always associated with various kinds of forest, either natural or such man-made habitats as coconut plantations. Where deforestation has been extensive, occasional specimens can be found around the root systems of remnant trees and in other microhabitats combining shade and moisture. The lowland

forms occur deeper in the soil and may now be patchily distributed.

The climatic and food preferences of these snakes also explain some aspects of their present distribution. When forested regions are transformed into more or less open areas of monoculture, shieldtails survive as long as the cultivated areas represent crops with shade and deep root systems, such as exemplified by tea and cardamom. Such environments favor large populations of earthworms, unless these are limited by applications of inorganic fertilizers and biocides. The population of predators on shieldtails is reduced as habitat diversity is diminished. Consequently, enormous concentrations of these snakes are found in some areas of cultivation.

There are distributional factors that we do not yet understand. Some species of shieldtails now occur in extremely limited areas, one species is known from a space the size of a football field. As in many attempts to reconstruct the past, we are left with a statement of what possibly occurred and the hope that further analyses will continue to reduce the uncertainty. Studies thus far suggest that although shieldtails do not appear to be endangered as a group, some specialized species may well be. This being the case, one wonders how many shieldtail species have already become extinct? □

With their flattened bodies, a few specialized parasitic mites are able to move about beneath the scales of a shieldtail's skin. Walking upside down, they suck the snake's blood through the "soft underbelly" of each scale.



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Unusual Star Quality

A recently discovered erupting star with peculiar emissions is under worldwide watch

In October 1976, an astronomer at Moscow University reported the discovery in the constellation Sagitta of an eleventh-magnitude star with a "remarkable" spectrum. The astronomer, O. D. Dokuchaeva, however, could find no star of that brightness at the right place on Palomar Observatory Sky Survey photographs of the region made in 1950. Instead, there was a much fainter, very red star, of only the seventeenth magnitude. A search through the files of the Sternberg State Astronomical Institute in Moscow turned up a series of photographs of the area made since 1898. Some of these pictures were capable of revealing stars as faint as seventeenth magnitude, while others, of lesser quality, recorded only those stars of thirteenth magnitude or brighter.

Dokuchaeva concluded that the star had always been at least as faint as those limits until April 1975. Then, during the interval from April to September, the object underwent a spectacular five-magnitude increase, brightening by a factor of 100. From September 1975 until its discovery in 1976, the star fluctuated irregularly between the eleventh and twelfth magnitudes. Previously unnamed and not even numbered, the object was now given the name HM Sagittae, denoting a star of variable brightness in the constellation in which it was found.

Some gaps existed in the photographic records at Moscow, but a later search through the extensive files of the Harvard College Observatory confirmed that HM Sagittae remained dim from at least the turn of the century until the April 1975 outburst. This indicates that the latter phenomenon was not a common occurrence in the star, like the regular brightness changes of the variable star Mira. Instead, it might be an event of unique physical significance.

Among the peculiarities in the spectrum of HM Sagittae that had attracted Dokuchaeva's attention were bright lines. They resembled typical features in the spectrum of a nebula, although no nebula is visible at the position of HM. In addition, the "continuum," or general background of light in the spectrum, was much stronger in relation to the bright lines than is usual in the case of a nebula. It was more like the continuum of a star.

Systematic investigations of HM Sagittae were initiated after the October 1976 report. Among the first was a program of spectroscopic observations that began on November 19 at the

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Asiago Astrophysical Observatory in Italy. There, three astronomers from the University of Padova found that the bright lines in the spectrum of HM Sagittae were very narrow and that most of the more intense ones were what is called "forbidden."

Forbidden lines consist of light produced by electrically excited atoms in processes that require relatively long times from the moment of excitation to the moment of light emission. Under normal conditions these lines are not generated in stars or in the laboratory because the gas is dense enough to insure that one or more particles will collide with a temporarily excited atom before it has emitted the light. The collisions alter the physical states of the atoms, causing them to emit at other, nonforbidden wavelengths. Thus, the same type of atom will produce one set of lines under stellar or laboratory conditions and another set—the forbidden lines—in a rarefied nebula.

Nebulae that produce such lines are of two general types: large, diffusely shaped clouds, consisting of interstellar gas that is heated and excited by nearby hot, massive young stars that have formed from the gas (the Great Nebula in Orion is an example of this type), and smaller, round objects, known as planetary nebulae, consisting of material expelled from and heated by a central star. The central stars of the latter are old objects—the small, hot cores (according to theory) of former red giants that have ejected their huge, cool outer layers. The Ring Nebula in Lyra is the most familiar example of a planetary nebula.

The Italian astronomers confirmed the Soviet observation that no nebula is visible around HM Sagittae and suggested that the source of the forbidden lines must be a relatively compact region, as compared with the Ring Nebula, which has a diameter of about four trillion miles. The compact size might be understandable if a planetary nebula was in the process of formation, was, say, a "protoplanetary" nebula still close to its parent star.

Many of the lines seen in the spectrum of HM Sagittae, as observed in November 1976, are also found in the spectra of novae. In a nova, however, the small nebula ejected by the explosion shoots out into space at speeds as high as 1,000 miles per second. As a result, the spectral lines are blurred by the Doppler effect: part of the nebula rushes toward the observer, producing blue-shifted light; part flies away from the observer, creating red-shifted light.

Because many of the bright lines of HM Sagittae were of the forbidden type, the Italian astronomers knew that they must originate in a low-density gas. From the narrowness of the lines, the observers deduced that the gas could not be rapidly expanding. The brightness of the lines made it possible to estimate how large a sphere around the star the glowing cloud must occupy. The radius of that sphere is much larger than the distance the slow-moving matter could have traversed in the interval between the April 1975 eruption and the November 1976 Asiago observations. From this consideration, the Italian team concluded that the nebular material was expelled from HM Sagittae long before 1975 but was now being made to glow by ultraviolet radiation from the recently erupted star. In a paper prepared in April 1977, they speculated that the eruption had uncovered a hot stellar surface, and they predicted that infrared and radio emission from the freshly erupted material might be detectable.

Unknown to the Italians, a specialist in radio observations of peculiar stars, working in Canada, had searched unsuccessfully for radio emission from HM Sagittae in November 1976. He tried again on May 9, 1977, with a radiotelescope at the Algonquin Radio Observatory in Lake Traverse, Ontario, and this time he found that a radio source had appeared at the star's position. The discovery of the new source of radio emission was confirmed with other radiotelescopes at Effelsberg, Germany; Parkes, Australia; and Westerbork, Holland. The Italians' prediction of infrared emission was also confirmed. This radiation was first detected on June 9, 1977, by astronomers from the University of Minnesota. Additional infrared studies were made by astronomers at the University of California, San Diego.

The infrared research revealed three notable properties of HM Sagittae. First, the bright lines found in the infrared spectra of planetary nebulae are *not* present, so the similarities of HM and such nebulae do not extend to the infrared wavelength region. Second, an infrared continuum with properties indicative of an emitting region at a temperature of 1,250°F was discovered. Third, there is a strong band of enhanced infrared light near the 10 micron wavelength. (A micron, one-millionth of a meter, is about 1/25,000 of an inch.) Emission of this type is

A REPORT ON THE AMERICAN FOREST

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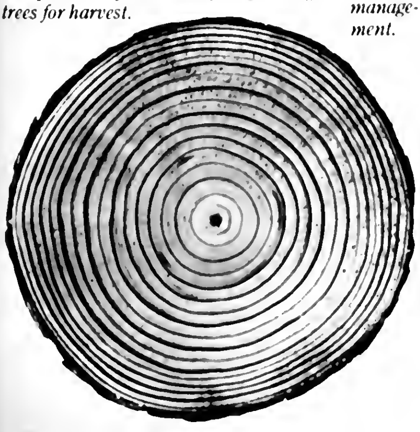

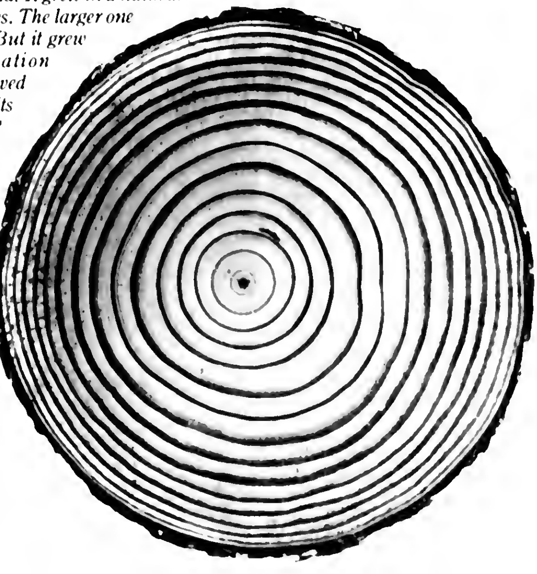

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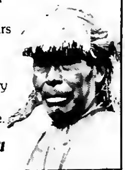

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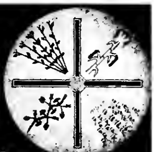

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identified with radiation from warm silicate dust, a type of microscopic rock particle.

Monitoring lapsed from January to March 1977, when HM Sagittae was too close to the sun for visual observation. Then on April 25, spectroscopic studies resumed at Asiago and the Italian team discovered a major change in the star. Although the narrow emission lines were still present, there was now a set of very broad bright lines in the spectrum of HM. As previously explained, broad lines are evidence of rapidly escaping material and are seen, for example, in the spectra of novae.

Further details of the wide bright lines came from several sources: the Minnesota astronomers who observed HM Sagittae at Kitt Peak National Observatory in June 1977; colleagues of mine at Goddard Space Flight Center who observed HM with a NASA ground-based telescope during the summer; and a University of Washington astrophysicist who obtained exceptional quality spectra of HM with the 200-inch telescope at Mount Palomar on September 2.

The Italian astronomers rejected the possibility that HM Sagittae is a nova. In novae, there is a systematic progression of spectral changes as the ejected nebula expands outward from the parent star. In the spectra of HM Sagittae, this progression did not occur, and indeed, bright lines that usually appear last in the novae were found in the earliest observations. Both the Italian team and the NASA observers noted that the broad emission lines also resembled those found in Wolf-Rayet stars. These objects, named for a pair of nineteenth-century French astronomers, are very hot blue stars that drive material into space in a steady fast flow by means of powerful stellar winds rather than by an eruption. The Italian and NASA astronomers concluded that HM is a recently formed planetary nebula excited by a Wolf-Rayet star. However, this interpretation was based only on the visible-light spectra and not on the infrared observations from Minnesota and San Diego.

The San Diego astronomers are among those who have proposed an interpretation that does take the infrared measurements into account. According to them, the infrared continuum comes partly from a cool red star and partly from a warm cloud of dust that surrounds both it and a very hot companion. Ultraviolet light from the companion warms the dust, causing it to glow in the infrared (and notably in the 10-micron silicate emission wavelength). Presumably by filtering through gaps in the dust cloud, the ultraviolet also excites the thin outer gas region, which then produces the forbidden lines.

According to the San Diego theory, HM Sagittae is a symbiotic star. Members of that class are defined as stars whose spectra show emission lines characteristic of gas excited by a hot star, together with other features that are typical of a cool red giant, perhaps a long-period variable star like Mira (see "Now You See It; Now You Don't," *Natural History*, June-July 1978). Most specialists believe that symbiotic stars are binary systems; others maintain they are single stars.

Two astrophysicists at York University in Toronto claim that all the phenomena found in HM Sagittae can be explained by a single star. They believe that HM is indeed a protoplanetary nebula. They ascribe the large, thin gas cloud to slow-moving material that streamed off a red giant star long ago in a mild stellar wind. The dust cloud represents material from the recently ejected outer layers of the red giant. The source of ultraviolet radiation is the remaining hot core of the giant, which has a faster-flowing stellar wind. As the latter wind material catches up with the thin, older gas, a shell forms from colliding matter, producing a true planetary nebula.

Other astronomers disagree and one Texas observer has reported evidence for infrared intensity variations. These are ascribed to pulsations of a still-intact red giant. This finding supports the symbiotic binary star theory of HM Sagittae, but the published evidence from Texas looks weak to me.

The correct explanation of HM Sagittae may be debated for several decades. The University of Washington astronomer, who has the best spectra of the star, thinks it possible that HM is really a peculiar slow nova. On the other hand, if the theory of the York University astrophysicists is correct, then the recently erupted material will be fully incorporated into a planetary nebula about sixty-five years from now and the disagreement, if not already settled, will finally be resolved.

Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun moves eastward through the stars of Aries until May 14. Then it enters Taurus and moves between the Hyades and the Pleiades. During the first half of the month it is still shifting rapidly northward, and the days swiftly lengthen in response. But once the sun is in Taurus, the trajectory of its path relative to the equatorial plane will flatten out as it approaches the summer solstice.

The waxing crescent and gibbous moon will be above the horizon at sundown, and will brighten the early evening sky during the first ten days of May and again in June. First-quarter moon will be on May 3 and June 2; full moon will be on May 11 and June 10. When past full phase, the moon will rise after sunset, later each night, and will gradually become a prominent object in the morning sky. Last-quarter moon is on May 18 and June 17, and the lunar cycle will end with the new moon of May 26 and June 24. The waxing crescent will return to the evening sky on the last days of both months. Apogee (where the moon is farthest from the earth) is on May 4 and June 1 and 29; perigee (where the moon is nearest the earth) is on May 18 and June 13.

Stars and Planets Jupiter and Saturn are the dominant planets in the evening sky this month. Jupiter is the bright object that appears in the southwest after dusk all month. The stars of Leo (Regulus is the brightest) are to the left and higher than Jupiter; Saturn is close by to the left of Regulus, and about equal to it in brightness. Jupiter sets approximately at midnight or earlier; Saturn soon after midnight. The moon will introduce you to the two planets in early May and again at the end of May and the beginning of June. While Mercury, Venus, and Mars are morning stars, none is well located for viewing in the morning sky.

May 2: The bright object near the moon tonight is Jupiter.

May 5: The Eta Aquarid shower (up to 20 meteors per hour) reaches maximum late in the day. The waxing gibbous moon tonight is between Saturn (to the left) and Regulus (to the right), moving closer to Saturn.

May 9: Saturn ends its retrograde motion and begins moving slowly east (away from Regulus) through the stars.

May 20: Venus and Mars are in conjunction early today. Find Venus first, low in the east just after dawn, but very bright. Mars is nearby, but much dimmer. Binoculars will help.

May 23–24: The late crescent moon joins Venus and Mars in the morning sky. The moon is to the west (right) of the planets on the morning of the 23rd, to the east (left) and lower on the 24th.

May 29: Mercury is in superior conjunction, in line with but beyond the sun in our sky. The planet now becomes an evening star.

May 30: The moon is near Jupiter again tonight. Both are well up in the southwest at dusk, setting before midnight.

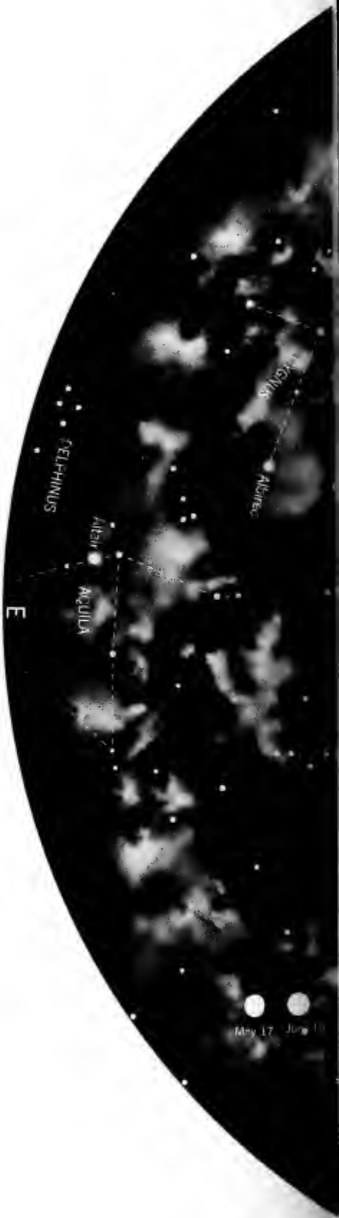
June 1–2: The moon moves past the star Regulus (in Leo) and Saturn these two evenings, below Regulus on the night of the 1st, past Saturn by the 2nd.

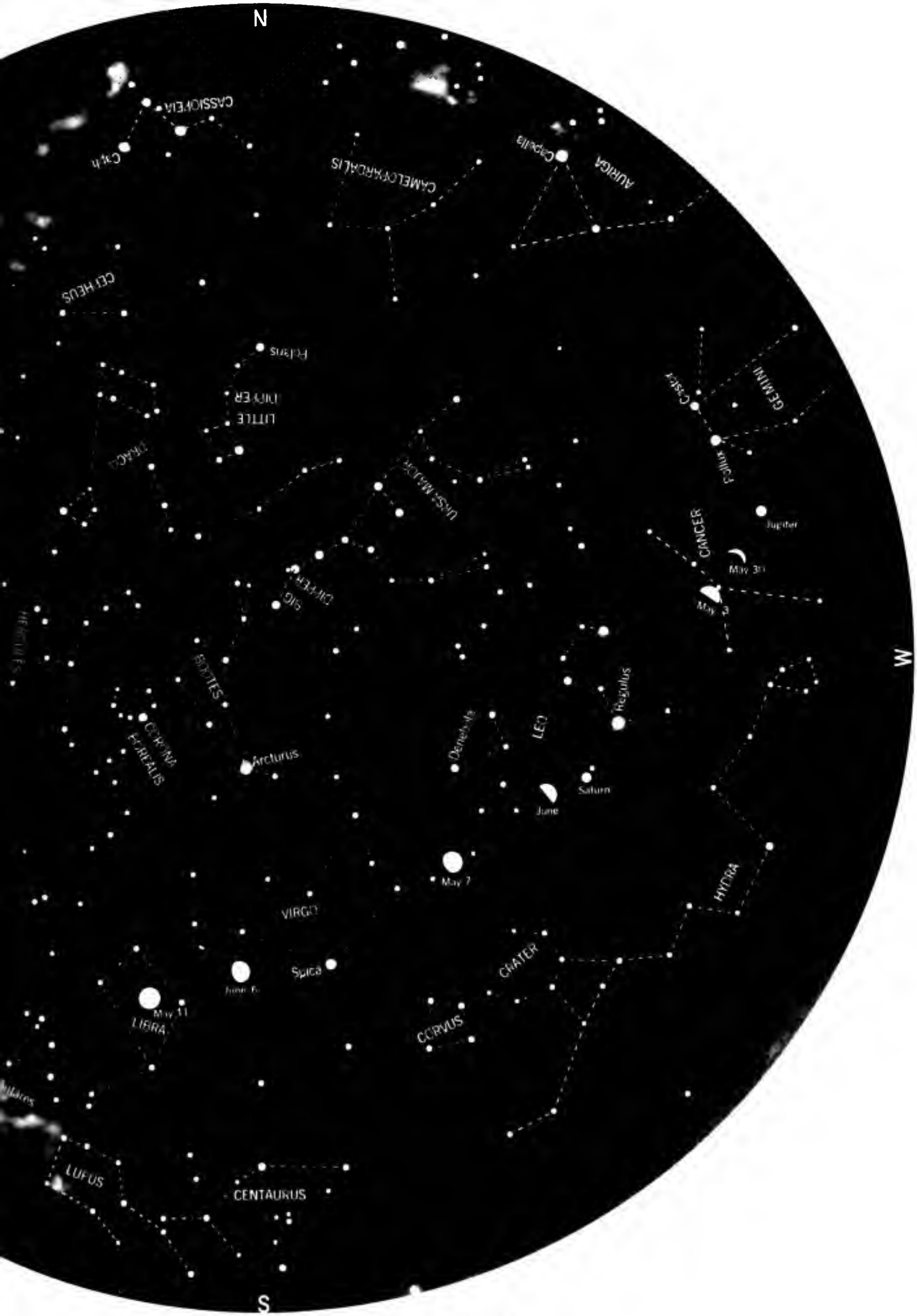
June 13: The earliest sunrise of the year occurs today in the mid-latitudes of the Northern Hemisphere.

June 20: The star near Venus this morning is Aldebaran in Taurus, not Mars. They are similar in appearance, but Mars is now higher and to the right of Venus, rising a good hour before Venus does.

June 21: When the sun arrives at the summer solstice today at 6:56 P.M., EST, summer begins in the Northern Hemisphere.

★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:20 P.M. on May 1; 10:25 P.M. on May 15; 9:25 P.M. on May 31; and 8:25 P.M. on June 15; but it can also be used for an hour before and after those times.

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Animal Art

Squirrel. *Chromolithograph after an original drawing by Nicolas Huet. From Henri and Alphonse Milne Edwards's* Recherches pour servir à l'histoire naturelle des mammifères, *1868–74.*

THE ART OF NATURAL HISTORY, by S. Peter Dance. *The Overlook Press, $60.00; 224 pp., illus.*

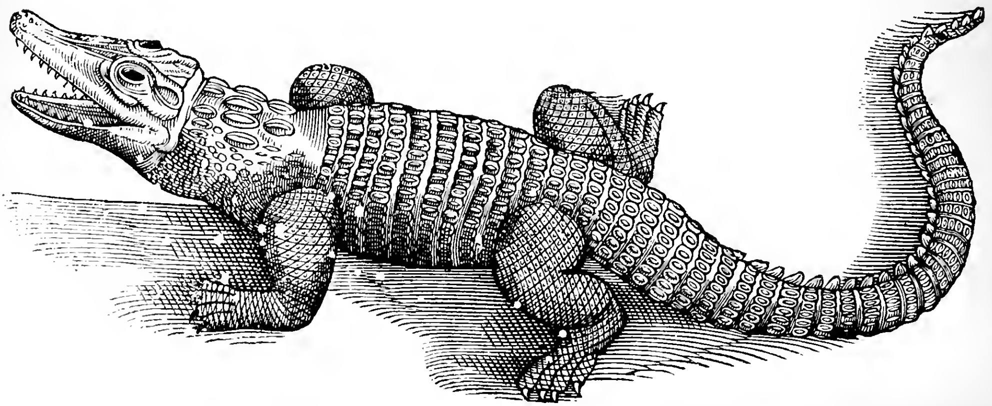
"The significance of animals in our lives and in the development of art," observes S. Peter Dance, English naturalist-author and compiler of the illustrations in this sumptuous, oversized book, "can hardly be overstated," for "the beginning of all art, was animal art." This thesis is argued persuasively in the first chapter, which covers some 30,000 years, from the cave paintings of Paleolithic man to the end of the Middle Ages, drawing liberally upon the cultural resources of both the Near and the Far East as well as the artistic heritage of Western civilization.

But there are, necessarily, self-imposed limits. The main emphasis of the volume is on the development of zoological illustration as found in books, that is, by some means of duplication, during the Renaissance and onward to the nineteenth century. Although much is excluded—for example, salon painting and carved figures in relief, intaglio, or in the round—a vast terrain remains for this conducted tour. The author takes us through early press books down into the sixteenth and seventeenth centuries, then moves "out of the age of . . . fabulous creatures into the . . . organized world of zoological science." And so on to the animal art that kept pace with the scientific thought of Buffon, Linnaeus, and the Enlightenment.

In the early nineteenth century, animal iconography made an unpromising beginning, repeating the familiar representation of static creatures, until by a kind of back-formation, new printing techniques moved the artists toward naturalness and the vivacity of the living organism. This was especially true of the lithographic revolution, with contributions from stipple, mezzotint, and the aquatint plate, which was celebrated for its clarity and luminosity. John James Audubon utilized this last process, with the fortunate collaboration of the engraver Robert Havell the Younger, in producing his famous *Birds of America*, a copy of which set a world auction record in 1977, going for $396,000.

So much for a quick journey through time from the astonishing sensibility of Stone Age art to the luxurious illustrated books designed for the private

Crocodile. A woodcut from Edward Topsell's History of Four-Footed Beasts and Serpents, *1658.*



libraries of "Noblemen and Gentlemen wishing to become subscribers. . . ." Mr. Dance's book descends worthily from this aristocratic tradition. Exquisitely printed in Holland, it offers 250 black-and-white pictures and 65 full-color plates, the subjects drawn from British museums and libraries. Captions give full information, naming the artist, the book, the date, and the printing process. The book is indexed by artist, author, and title and has an appendix containing brief biographies of the authors, artists, and engravers mentioned. A useful essay explains the development of printing methods. The text has the easy erudition and literary grace that so often distinguish British writing. Acute observations with philosophic overtones are scattered throughout the narrative, as in the chapter entitled "Mirrors to Ourselves," where Mr. Dance, speaking of the sporting context of much good animal illustration, writes, "Ironically, the most sympathetic understanding of animals has often been found in people who derive pleasure from hunting and killing them."

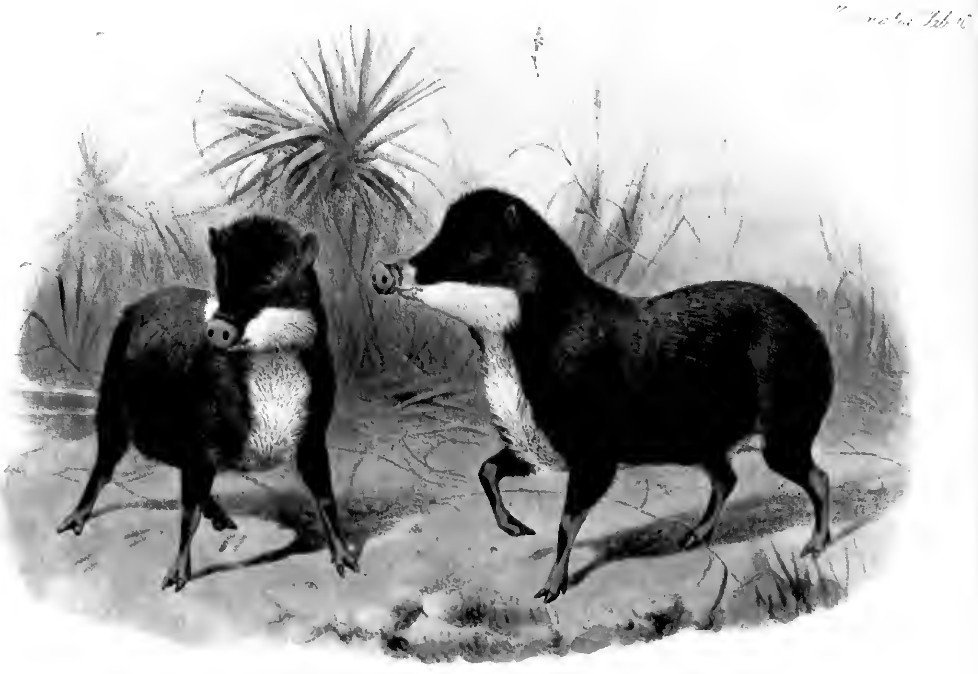
The author-compiler is himself a leading authority on conchology and an antiquarian bookseller; that is to say, a scholar. He loves both animals and books. The audience he aims at in *The Art of Natural History* is that of the intelligent, responsive, general reader. Thus aesthetic considerations are balanced against the claims of scientific zoology. "Indeed," he writes, "there is often much pleasure to be derived from illustrations that are far from accurate," and "since many early animal pictures were charming results of imperfect knowledge," he has preferred to use general descriptions rather than modern taxonomic classifications.

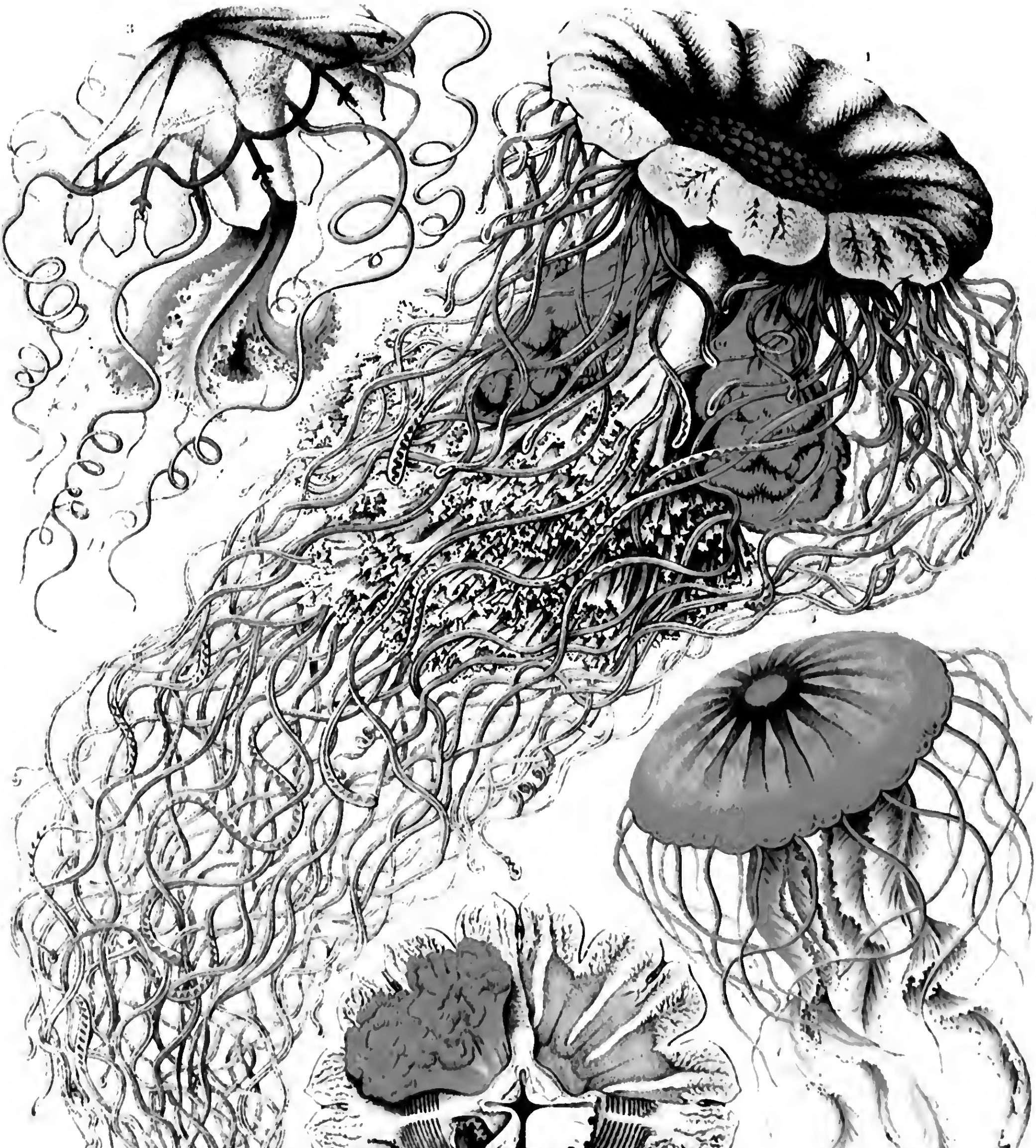
"Why animals and plants are as they are," the late distinguished entomologist William Morton Wheeler wrote, "we shall never know," but he pointed out that they are our only companions in this universe, and thus "a perennial joy and consolation." In this study of animal illustrators and their work, the author has successfully captured in picture and text the eternal fascination, the mystery, the charm, and the "joy and consolation" of the animal kingdom.

Gerald Carson, author and social historian, is a frequent contributor to Natural History.

Various species of Semaeostomeae, a group of jellyfish. Chromolithograph from Ernst Haeckel's Kunstformen der Natur, *1904.*

White-lipped Peccary. Hand-colored lithograph by Joseph Wolf and Joseph Smit. From Edward Alston's monograph of the Mammalia in Biologia Centrali-Americana, *1879–82.*





The Upper Crust

Strudel dough must be paper thin and flaky

Maybe I only dreamt it, but I vividly recall a scene from a brilliant Yugoslav film about a telephone operator who falls in love but takes time out from bedroom sporting to stretch strudel dough into a papery blanket so thin it could have made a diaphanous robe for her naked body.

Even fully clothed, a person making strudel dough is engaged in an act of sensuality, but one that is pure—a ritual of hands and translucent dough and white tablecloths. Strudel is a paradox. As one of the thinnest and most delicate of all doughs, it occupies an exalted position in the world of pastry. But it has never lost its strong connection with peasant life. In Vienna, one does not go to elegant Demel's for strudel. It isn't bad there, but the height of flaky, authentic apple strudel is served in a plain little Carinthian restaurant that doesn't even list itself in the telephone book. In the back, behind the scenes at Bei Max (15 Herrengasse), Frau Schmölzer practices the ancient art of strudel to perfection.

As Central European villagers have done for centuries, she mixes a dough with plenty of high-gluten flour in it and kneads it as one kneads dough for bread. The kneading (and the high-gluten flour) makes the dough stretchable. After a rest, the strudel dough is placed on a big table covered with a floured white tablecloth. Now comes the part I think neither you nor I will ever master. The strudelmaker walks around the table and stretches the dough with the backs of the hands, then reaches underneath and stretches it some more. Next, the dough is kneaded a second time and restretched. Then it has to be dried a bit. George Lang, author of *The Cuisine of Hungary*, saw this process in a little shop in Hungary, a place where they made nothing but strudel. The drying there was speeded up with an overhead rotary fan. The point of the drying stage, however it is done, is to keep the dough from sticking when it is rolled.

Before this final rolling, you spread melted lard or butter on top of the stretched dough. Lard is traditional for all strudels except those filled with cottage cheese, which marries better with butter. Lard also produces a crisper product, just as it does in traditional American pie crusts.

Now it is time to finish the extravaganza. Pick a filling. There is no logical limit to what can be put inside a strudel. Lang mentions not only the familiar cheese and apple and poppyseed fillings but goes on to suggest a mixture of jam and ground almonds, bread crumbs soaked in wine, almonds and potato, chocolate and almonds in a kind of custard, and even savory fillings such as cabbage and mushrooms.

With any of these fillings, the procedure is the same. Spread the filling on one end of the dough sheet, covering a third to a half of the dough. Then pick up the tablecloth at the filled end and lift it high enough so that gravity will make the dough roll up on itself, wrapping the filling in many, many windings of thin dough, each separated from the next by lard or butter in a whirlpool of pastry (*Strudel* means "eddy" or "whirlpool" in German).

While the strudel bakes, the interlarding fries each thin layer of dough individually and makes each one crisp and flaky. It is as if you had hidden a miniature cook inside each turn of the dough. This ingenious method is typical of a whole family of similar flaky pastries that crop up in several cultures.

Strudel itself was brought to Hungary and Austria by the Turks in the sixteenth century or before, when the Ottoman Empire threatened the eastern frontier of Christendom and occupied large stretches of territory that only later came under Hapsburg dominion.

"If you have any doubts, ask one of the men who run sports fishing boats in the Gulf," says H. E. Braunig, a Manager of Environmental Affairs at Gulf Oil. "When they want to guarantee their customers a good day's fishing, they head straight for the oil platforms.

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Gulf people: meeting the challenge.

No one can really say what Turkish pastry dough was like in those days, but we have modern phyllo (from the Greek *phyllon*, or "leaf") dough to give us a good idea. Turks call the same papery sheets *yufka*. Tunisians say *malsouka*. It can be bought ready-made and frozen (phyllo freezes exceedingly well) in Greek and Arab specialty shops. The basic dough is a mix of flour and water, kneaded hard and long, then stretched to the limit of the dough's capacity to stretch. Commercial phyllo is thinner and weaker than strudel leaves. It is stretched in a slightly different manner and does not have to hold the heavy fillings that strudel does.

If you buy a package of phyllo, the key to success is to keep the sheets of finished dough under a damp towel. This is essential, because otherwise the sheets dry out, turn brittle, and cannot be folded and rolled around the myriad stuffings that the combined ingenuity of the cooks of the Levant and North Africa have devised over centuries.

Almost everyone will have tried the Greek feta cheese and spinach pies called *spanakopita*. Meat and chicken fillings are also traditional. But, of course, the best-known use of phyllo is for the dessert called *baklava*, a double-crusted phyllo pie filled with nuts (walnuts, almonds, and even unsalted pistachios) and a honey-based syrup flavored with cinammon and cloves or, in the Middle East, with cardamom and rosewater. *Baklava* has eight or more sheets of dough on the top and as many on the bottom. Slightly fewer sheets are used for the custard pie of Greece, *galaktoboureko*. Phyllo can also be rolled around a filling of egg and nuts for *floyeres*, Greek pastry flutes.

Morocco and Tunisia ring a few notable changes on the basic phyllo theme. Actually, their triangular savory pastries are most authentically made with a leaf dough called *warka*; from reading about its preparation, I conclude it is the trickiest thing in the world for a person to make at home. Paula Wolfert, whose first attempts at the job were, she confesses, "farcical," requires six dense pages of instructions and drawings to explain the technique in her book *Couscous and Other Good Food from Morocco*.

You start with hard wheat or semolina flour. After kneading and resting the flour-water dough, you tap a nugget of dough against a greased, heated metal surface leaving a thin film of pastry on the metal with each tap. Working your way around the metal surface, you produce a sheet of thin dough, which you then peel away. Forty leaves of *warka*, the number you need for *bisteeya*, the fabulous Moroccan pigeon pie, may take three hours to make, and they will only keep for a couple of days.

Warka leaves, it turns out, are made in the same way as Chinese spring roll skins, except that spring roll skins are made from wheat starch and bake badly, turning to leather easily. *Warka* leaves have the thinness of phyllo and strudel but they are crisper because they have been cooked on one side.

Slight differences among the leaf doughs produce slight but crucial differences in the taste of the final dish. You can make *braewats*, the stuffed, baked pastry triangles of Morocco, with phyllo, but they will taste different from the real thing done with *warka*. Likewise, the deep-fried stuffed triangles of Tunisia, *briks*, will turn out differently with *warka* or spring roll (the optimal substitute) wrappings.

Even with these individual peculiarities and the very detectable variations in taste and texture they produce, the several leaf pastries of the Levant, China, and the Maghreb are all close cousins. They are basically very thin sheets of dough that can be greased and stacked. They have to be layered in one way or another to turn into a flaky pile. And however ingenious strudel and *warka* and phyllo and spring roll skins may be, they are hard to make, one at a time, over and over.

They order these things differently in France. The French alternative to these other leaf pastries, *pâte feuilleté* (literally "leaf pastry" or more conventionally "puff pastry"), is really a shrewd short cut. Anyone who has rolled and turned classic puff pastry for the number of hours it requires may want to protest. But if one takes into account that almost all the preparation time for puff pastry occurs while the dough is chilling in the refrigerator, my point becomes clearer. Puff pastry also requires almost no kneading. It is essentially a sandwich of dough and butter folded over and over on itself; chilled; folded over and over again; chilled and folded over until eventually there are hundreds of thin layers of butter and flour in the same flat piece of dough. It is like a ready-made stack of phyllo leaves. And a *mille-feuille*, or napoleon (the custard-filled paradigm of all French pastries), is tantamount to a prefabricated *galaktoboureko*. In other countries it is possible to buy raw, fresh puff pastry in ordinary retail outlets. And there are some sources for it here. But it is, in fact, simpler to buy ready-made frozen phyllo or strudel leaves, which are basically easier to work with and of higher quality than most prepared puff pastry. Here then is a recipe for a napoleon that can be made in less than a half hour with strudel leaves. If you want to substitute phyllo, double the quantity of leaves in the recipe.

Mille-feuille à la Hongroise
(Hungarian napoleon)

2 frozen strudel sheets (see note), held at room temperature for at least 3 hours
4 tablespoons melted, unsalted butter
1 cup heavy cream (approximately), stiffly beaten

1. Preheat oven to 375°F and grease a cookie sheet.
2. Open the package of strudel and remove two sheets. Set one aside under a damp dish towel so that it will not dry out.
3. Spread out the other strudel sheet on a work surface. Do not worry if there are small breaks in the dough.
4. Paint the strudel sheet with melted butter. Fold the sheet. Paint the top of the folded sheet with more melted butter. Fold again. Paint with more butter. Fold again. This should leave you with a rectangular package containing eight layers of buttered leaves. Place the package on the cookie sheet.
5. Remove the second strudel sheet from under the towel and repeat step 4.
6. Bake both folded sheets for 5 to 10 minutes until nicely browned. Remove immediately from baking sheet with a spatula. Let cool on your work surface, not on a rack.
7. Put one of the strudel packages on a serving dish and spread it carefully with as much of the whipped cream as you want. Place the other strudel package on top. Serve.

Yield: Six servings

Note: Frozen strudel sheets are available at Paprikas Weiss, 1546 Second Avenue, New York, NY (212) 288-6117.

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

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Additional Reading

Women Astronomers (p. 12)

A special issue of *Signs: Journal of Women in Culture and Society* (Autumn 1978) was devoted to women, science, and society. The illustrated *Harvard College Observatory: The First Four Directorships, 1839–1919,* by Bessie Z. Jones and Lyle G. Boyd (Cambridge: Harvard University Press, 1971), contains much of the history of American astronomy and quotes liberally from personal and scientific correspondence. Of particular interest is the chapter on "A Field for Women." *Notable American Women, 1607–1950: A Biographical Dictionary*, a helpful three-volume reference, was edited by Edward T. James and Janet W. James (Cambridge: Harvard University Press, 1971). More information on women astronomers can be found in *Academic Women*, by Jessie Bernard (University Park: Pennsylvania State University Press, 1964).

Cicadas (p. 38)

The only detailed literature on periodical cicadas is in scientific publications. The evolution of the cicada is discussed in *The Evolutionary Relationships of 17-Year and 13-Year Cicadas, and Three New Species (Homoptera, Cicadidae,* Magicicada), by Richard D. Alexander and Thomas E. Moore (Ann Arbor: Miscellaneous Publication of the Museum of Zoology, no. 121, University of Michigan, 1962), and "The Periodical Cicada Problem. II. Evolution," by L. M. Lloyd and H. S. Dybas (*Evolution*, December 1966, pp. 466–505). Both publications contain additional references. An earlier, illustrated report is *The Periodical Cicada*, by C. L. Mar-

lott (U.S.D.A. Bureau of Entomology Bulletin no. 71, 1907). In "This View of Life: The 120-Year Bamboo Clock" (*Natural History*, April 1977, pp. 8–16), Stephen Jay Gould discusses the evolutionary advantages held by cicadas and other periodical life forms. The most recent reference is C. M. Simon's "Evolution of Periodic Cicadas: Phylogenetic Inferences Based on Allozymic Data" (*Systematic Zoology*, vol. 28, pp. 22–39).

Wolves (p. 46)

Most of the May 1967 issue of *American Zoologist* is devoted to the ecology and behavior of wolves. Two articles of special interest are "Wolf Predation and Ungulate Populations," by Douglas H. Pimlott (pp. 267–78), which offers an explanation of wolves' apparent inability to control moose and deer populations in environments drastically altered by man; and "Numbers, Turnover, and Social Structure of the Isle Royale Wolf Population," by Peter A. Jordan, Philip C. Shelton, and Durward L. Allen (pp. 233–52). Points raised in the latter article are explored further in "Continued Studies of the Status, Socialization, and Relationships of Isle Royale Wolves, 1967–1970," by Michael L. Wolfe and Durward L. Allen (*Journal of Mammalogy*, vol. 54, no. 3, 1973, pp. 611–35). Russell J. Rutter and Douglas H. Pimlott's *The World of the Wolf* (New York: J. B. Lippincott Co., 1968), a profusely illustrated introduction for children, includes the authors' personal observations. "The Social Organization of Wolves," by Jerome H. Woolpy, was published in the May 1968 issue of *Natural History*. More

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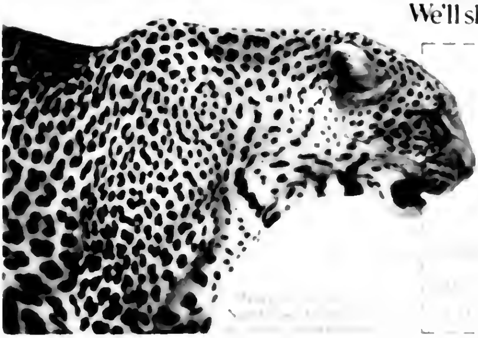

current is Rolf O. Peterson's *Wolf Ecology and Prey Relationships on Isle Royale* (National Park Service, Scientific Monograph no. 11, 1977), for sale by the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Moose and wolf interactions are discussed in "Mortality Patterns in the Isle Royale Moose Population," by Michael L. Wolfe (*American Midland Naturalist*, vol. 74, no. 2, 1977, pp. 267–79). Further references appear in the January 1979 issue of *Natural History*, which featured "Why Some Deer Are Safe From Wolves," by L. David Mech.

Saharan Dust (p. 54)

Man's impact on climate is a worldwide environmental problem. The conclusions and recommendations of thirty scientists from fourteen countries who met for three weeks to discuss the problem can be found in *Inadvertent Climate Modification: Report of the Study of Man's Impact on Climate (SMIC)* (Cambridge: MIT Press, 1971). *Desertification*, edited by Michael Glantz (Boulder: Westview Press, 1977), is a collection of

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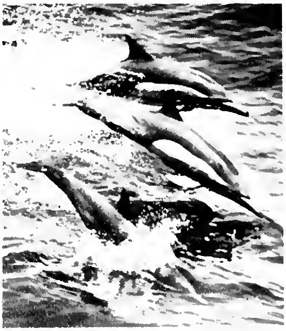

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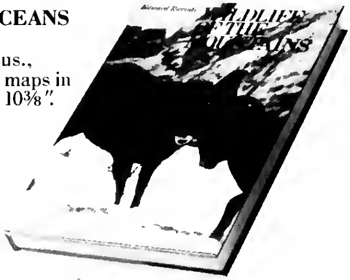

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papers, including considerable reference material, on the creation of desertlike conditions by human or natural causes. *The Surface of the Earth*, by A. L. Bloom (Englewood Cliffs: Prentice-Hall, 1969), part of the Foundations of Earth Science Series, is a readable, up-to-date introduction to all aspects of earth science. Also in the series, *Oceans*, by Karl K. Turkian (1976), covers the geology and chemistry of oceans, including the transport of particles and sediment. Suggestions for further reading are included.

Fire Blight (p. 62)

Part of the Agricultural Sciences Series, *Plant Pathology*, 3rd ed., by John C. Walker (New York: McGraw Hill Book Co., 1969), is a general reference book on plant diseases. Useful information specifically on fire blight can be found in several special bulletins. "Blight of Pears, Apples, and Quinces," United States Department of Agriculture Leaflet no. 187, 1972, is for sale by the Superintendent of Documents in Washington, D.C. "Fire Blight of Fruits and Ornamentals," by A. H. McCain (1975), is a University of California leaflet (no. 2715). "Fire Blight: Its Nature and Control," by Steven V. Beer (Plant Pathology Information Bulletin 100), can be obtained from Mailing Room, Building 7, Research Park, Cornell University, Ithaca, NY 14853.

Snakes (p. 70)

The taxonomy of snakes is briefly reviewed in *A Contribution to the Classification of Snakes*, by Garth Underwood (London: Trustees of The British Museum [Natural History], Publication 653, 1967). "Axial Differences in the Musculature of Uropeltid Snakes: The Freight-Train Approach to Burrowing," by Carl Gans, Herbert C. Dessauer, and Dusan Baic (*Science*, January 13, 1978, pp. 189–92), is an illustrated discussion of the muscle structure and burrowing techniques of shieldtail snakes. Other articles by Carl Gans are "Uropeltid Snakes—Survivors in a Changing World" (*Endeavour*, vol. 32, no. 116, pp. 60–65) and "Aspects of the Biology of Uropeltid Snakes," an illustrated paper on behavior, morphology, and mimicry, which appeared in *Morphology and Biology of Reptiles*, edited by A. d'A. Bellairs and C. Barry Cox (Linnaean Society Symposium Series, no. 3, 1976, pp. 191–204).

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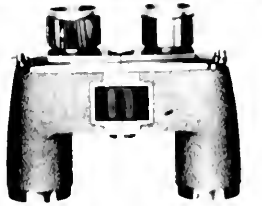

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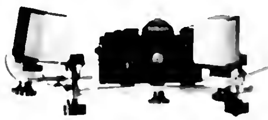

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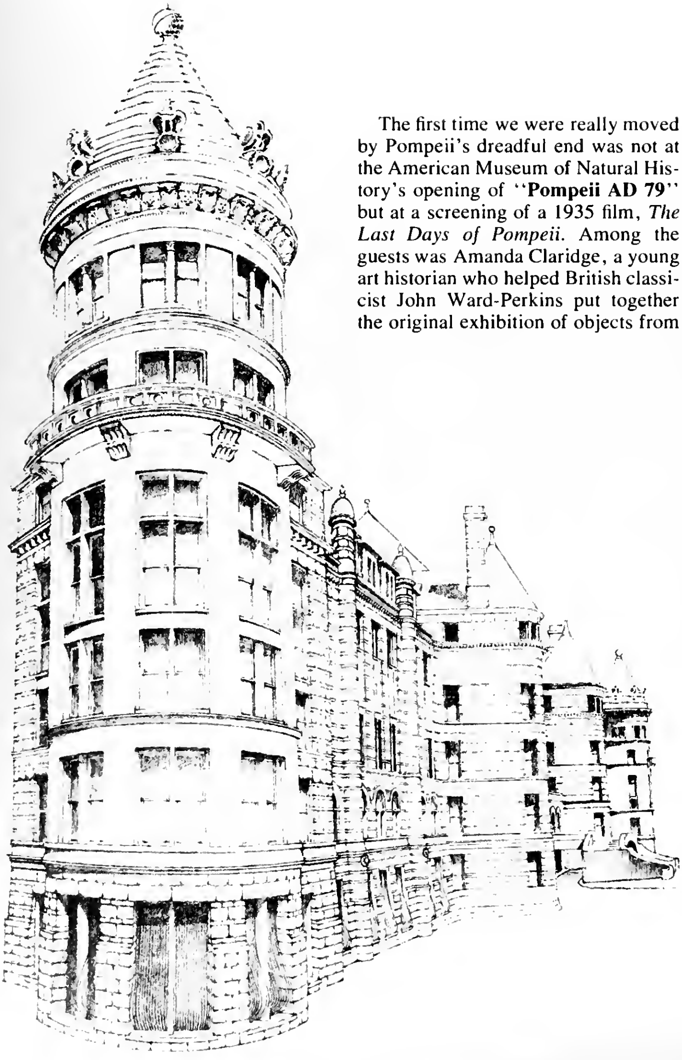

The first time we were really moved by Pompeii's dreadful end was not at the American Museum of Natural History's opening of "**Pompeii AD 79**" but at a screening of a 1935 film, *The Last Days of Pompeii*. Among the guests was Amanda Claridge, a young art historian who helped British classicist John Ward-Perkins put together the original exhibition of objects from Pompeii that opened at London's Royal Academy in 1977.

Claridge had come to the screening from Princeton, where she now teaches, and had spent an enjoyable morning casing a New York art dealer's classical wares and weeding out the fakes. She pronounced the sets of *Last Days* impressive and—excepting a "fascistic" colossus in the amphitheater—generally authentic. Indeed, Pompeii's paved streets, banquets, wineshops, gladiatorial gear, and buildings seemed as they should have been, and the movie captured for us the splendor of Pompeii's buildings and the blood lust of the crowd in the arena.

The film's historical accuracy was no accident, according to Eugene B. Stavis, director of the American Cinematheque at the Metropolitan Museum of Art. Stavis will screen and comment on this 1935 film on Wednesday May 2 and May 30 at 7:30 P.M. in the Auditorium; on June 6, he will present an early, 1913 Italian silent version of the *Last Days*, which carried accuracy to the point of actually filming at Pompeii. "In their early days," explained Stavis, "movies were continually under attack for moral turpitude. Historical accuracy was easy—it was something money could buy. D. W. Griffith was obsessed by it; he would put footnotes on his silents' dialogue."

Within five years of the appearance of commercial moving pictures in 1895, there was an English *Last Days of Pompeii*, based on Edward Bulwer-Lytton's romantic historical novel of 1834. (A beautifully illustrated edition is available in the Museum Shop for $7.95.) In 1833, during travels through Italy, Bulwer-Lytton, an impoverished English aristocrat who supported himself with his writing, saw the Russian painter Brioullov's picture of Pompeii's final moments. Bulwer-Lytton pronounced the canvas "full of genius, imagination, and nature." Pompeii, rediscovered in 1748, was being carefully excavated. Fascinated by the reappearing city, Bulwer-Lytton set out to write a novel that would accurately report the costume, architecture, and customs of the ancient inhabitants. Corpses found in the ash that had buried the city became the models for his characters. A friend's remark that a blind person would have been best equipped to escape from ash-darkened Pompeii gave Bulwer-Lytton his heroine, a blind Greek slave girl who guides a pair of lovers to safety.

In many respects, Bulwer-Lytton's tale of requited and unrequited love, jealousy, and magic in the humid southern Italian nights, accurately captures Pompeii's exotic mixture of Roman, Greek, and Egyptian culture. Some of the several silent film versions

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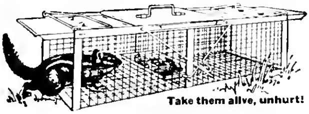

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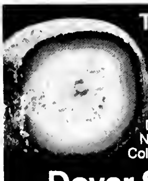

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of the novel must have been inspired by Vesuvius's activity in 1903, 1904, and 1906. But there were other reasons for the story's popularity. "As far as early filmmakers were concerned," said Eugene Stavis, "Bulwer-Lytton's novel had great visual possibilities and the inestimable value of being in the public domain."

The 1913 film, which closely followed Bulwer-Lytton's novel, was the first Italian version. Its director, Arturo Ambrosio, specialized, as did the entire contemporary Italian film industry, in spectacular epics that relied on natural disasters, hundreds of elephants, thousands of extras. D. W. Griffith's *Intolerance* (1915), for example, has a Babylonian sequence whose huge temples and milling crowds have many precedents in Italian silent epics. By 1935, American spectacles were as splashy as Italian ones, but they clung to historical accuracy.

The 1935 Hollywood version of *Last Days of Pompeii* had an original story, but its sets closely followed Bulwer-Lytton's descriptions. The directors, Merian C. Cooper and Ernest B. Schoedsack, came to films from adventurous careers as professional soldiers, newsreel cameramen, and explorers. In the mid-1920s, they made two well-received documentaries, one of which, *Grass* (1926), on nomads in Turkey and Persia, still crops up at anthropological film festivals. By 1935, Cooper and Schoedsack had already achieved a solid Hollywood special effects success with *King Kong* (1933); the pair went on to make a science-fiction classic, *Dr. Cyclops* (1940), and a King Kong offshoot, *Mighty Joe Young* (1949).

The hero of Cooper and Schoedsack's *Pompeii* is Marcus (Preston Foster), a blacksmith turned gladiator, whom hard times have taught that money is all that counts. He adopts Flavius, son of a gladiator he has slain, and to insure the child's well-being devotes himself to moneymaking. His business takes them both to "the most important man in Judea," whom Marcus mistakenly thinks is the Roman procurator Pontius Pilate (Basil Rathbone, not due to play Sherlock Holmes for another four years). Another important Judean (who never appears on screen) miraculously heals the injured Flavius.

Marcus returns home to become a rich man, manager of Pompeii's gladiatorial games and owner of the city's finest house. But his permissive child-rearing backfires: Flavius dedicates himself to the runaway slaves his father regularly sends to their death in the arena and is not interested in a career as Pilate's protegé in Rome. The film's special effects interrupt this clash between generations by combining the earthquake of A.D. 62 with Vesuvius's eruption in 79: as temple columns and Marcus's mansion crumble, lava—closely resembling eggplant parmigiana—drives a crowd of Pompeians into the sea.

There were more sophisticated effects in yet another Italian version, made in 1959, that starred Steve Reeves and returned to Bulwer-Lytton's plot. The English author who inspired all these films had gone to Pompeii because of a painting. His novel, in turn, gave rise to other canvases. Beginning in the third quarter of the eighteenth century, excavations at Pompeii and new eruptions of Vesuvius fired painters' imaginations.

On Wednesday evening May 9, at 7:30, Robert Rosenblum, professor of fine arts at New York University, will present a slide lecture in the Auditorium about some of these pictures entitled "Vesuvius to Apocalypse in Romantic Art, 1760–1914." Rosenblum will include French neoclassicist Pierre-Henry de Valenciennes's "The Eruption of Vesuvius and the Death of Pliny," which appeared in *Natural History*'s Pompeii supplement last month, and the Brioullov painting that so impressed Bulwer-Lytton. The Englishman particularly liked one detail, a child who, unlike its terror-stricken mother, is reaching for "a bird of gay plumage that lies upon the ground struggling in death, and all the child's gay delighted wonder is pictured in its face. This exception to the general horror of the scene is full of pathos, and in the true context of fine thought."

For information about the Wednesday evening programs, call (212) 873-7507.

May Events

This month's Family Membership Program, **The Vanishing Kingdom**, takes place on Saturday May 12, at 2:00 P.M. in Education Hall, when Jean Augustin of the Mammalogy Department will discuss endangered mammals. He will also show two films that present African mammals in their habitats and use sound tracks of only natural sounds. The program is free to members, 50¢ for the general public.

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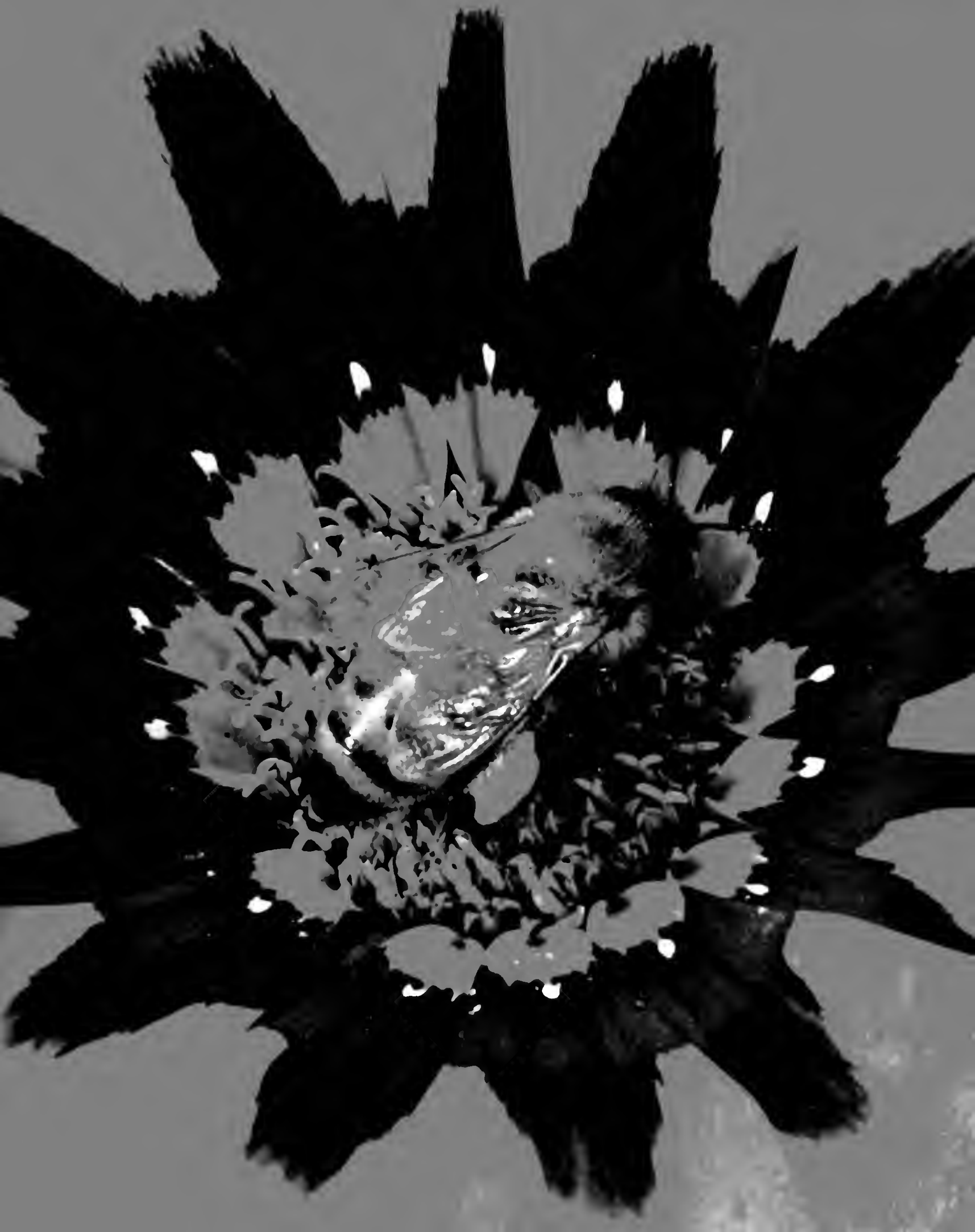


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Cover: *Without prior experience, a foraging honeybee can communicate the location of suitable flowers to other bees back in the hive. Yet, memory and learning on the job are also essential to bee behavior. Photograph by Kenneth Lorenzen. Story on page 66.*

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Authors

"I didn't know I had curly hair until I was a teen-ager," says **Erik Eckholm**, who spent a crew-cut youth. Now a senior researcher with the Worldwatch Institute, a Washington-based nonprofit organization concerned with global problems, Eckholm travels the world to gather material for books and articles on environmental subjects. Of his work he writes: "I have tried over the last few years to forge a new synthesis between concerns for environmental quality and concerns for economic development. Environmentalists and developers need each other if the goals of either are to be met." Eckholm is a graduate of Occidental College in Los Angeles and the School of Advanced International Studies at Johns Hopkins University. His current article marks his third appearance in this magazine (see "The Firewood Crisis," October 1975, and "The Unnatural History of Tobacco," April 1977).

Last fall, **Jon Lien** came across two humpback whales that had been ensnared by cod-fishing gear for three months in Trinity Bay, Newfoundland. No action had been taken because there was no established technique to free the whales, and the endangered status of the humpbacks made would-be rescuers wary. Nevertheless, Lien and his colleagues at Memorial University in Saint John's devised an apparatus to free the whales, which survived the ordeal. An associate professor of psychology at the university, Lien had done most of his work on communication and navigation in sea birds. He has now switched his attention to the problem of humpback whales and cod-fishing gear.

Coauthor **Bora Merdsoy**, a native of Turkey, is also connected with Memorial University's psychology department. A marine biologist, archeologist, and photographer, he is working with Lien to devise a means of making cod traps more readily discernible to whales. His other research interest is the natural history of the giant squid.

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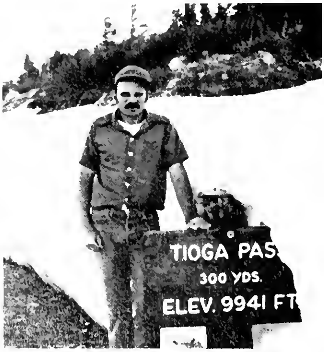
Paul W. Sherman claims that a pet turtle by the name of George turned him on to animal behavior at the age of four. His interest in pets became a profession, and he went on to study caterpillars in Colorado, bank swallows in Michigan, honey guides in Nepal, and ground squirrels in California. For the past five summers, he has observed a population of Belding's ground squirrels at Tioga Pass. This summer he is at it again. Sherman is in his first year as an assistant professor of psychology at the University of California, Berkeley. He writes, "I dream of being a really good skier and poker player, but realize that fishing and backgammon are more my speed."

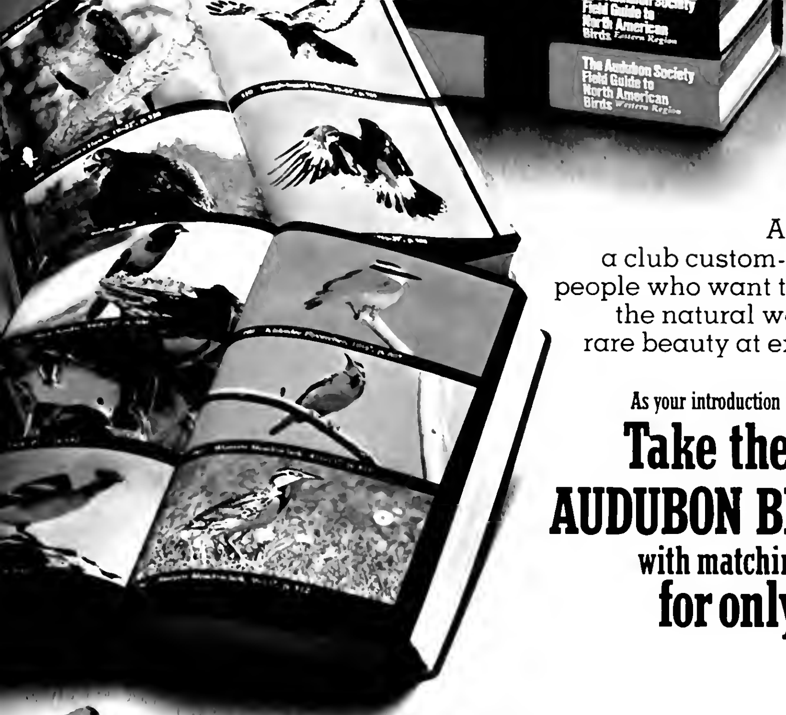
Martin L. Morton, a professor of biology at Occidental College and coauthor of "Four Months of the Ground Squirrel," has been involved with ground squirrels longer than Sherman. He was studying the reproductive biology of migratory birds at high altitude (in the Sierras) in the late 1960s when he became interested in the rodents because they were numerous, conspicuous, and aroused his curiosity. Morton has also studied the ecology of alpine amphibians. Both authors spend a lot of time in the mountains.



Daniel H. Janzen's investigations of why seeds mold, fruits rot, and meat spoils were "inspired by paying 95¢ for a rotten avocado." His article for this issue of *Natural History* was triggered by a slide of a moldy strawberry, which he screened at the 1977 meeting of the American Institute of Biological Sciences. Professor of biology at the University of Pennsylvania, Janzen now spends four to six months a year in Costa Rica, where he studies the ecological relationships between tropical animals and plants. Some of his conclusions about what goes on in natural and disturbed habitats have appeared previously in *Natural History*, in "The Deflowering of Central America" (April 1974), and "The Uncertain Future of the Tropics" (November 1972).

Bees play a large part in the life of **James L. Gould**. While still a student, he settled the question of whether this insect's dance language communicates anything by "getting bees to 'lie' about the location of food and then demonstrating that bees recruited by those dances were misled by the lies." As an assistant professor of biology at Princeton University, Gould spends a considerable amount of time experimenting with bees in an old barn. In addition to his regular teaching, he also gives a summer lab in bee behavior at the Marine Biological Laboratory at Woods Hole, Massachusetts. At present, Gould is writing a book on animal behavior for W.W. Norton and Co., "revamping a beat-up house, and studying the behavior of that most interesting of animals—a two-year-old child." Among future projects is an investigation of seemingly different "dialects" in bee language.

While investigating pioneer Plains cookery, **Roger L. Welsch** realized that he had to deal with the kitchen as the main access to the household. Thoroughly enchanted with folklore, he is studying tales of pioneer horse-trading and plans to research the meaning of the harvest, the form of obscene post cards, and a Willa Cather cookbook. An associate professor of English and anthropology at the University of Nebraska in Lincoln, Welsch spends his spare time at his 1872 log house on the banks of the Loup River in the central region of the state. Appropriately enough, he enters his house through the back door.



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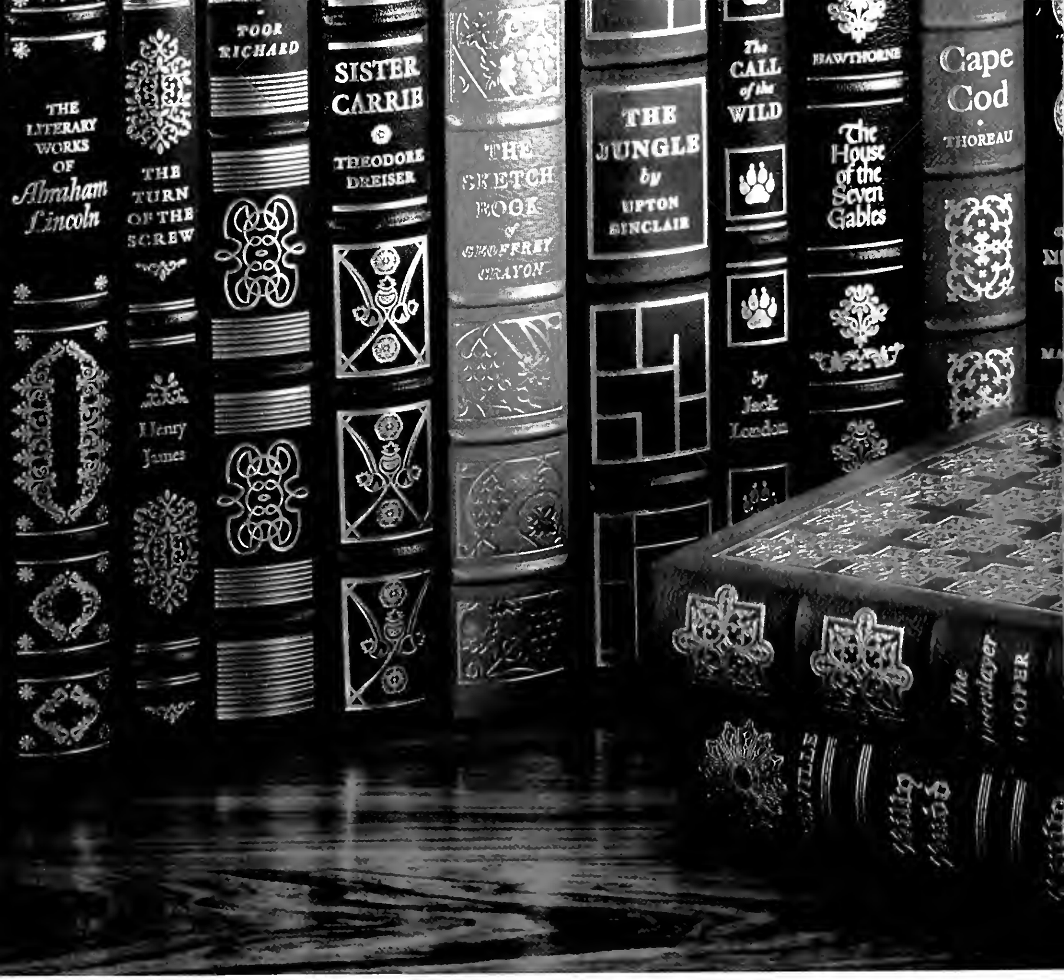

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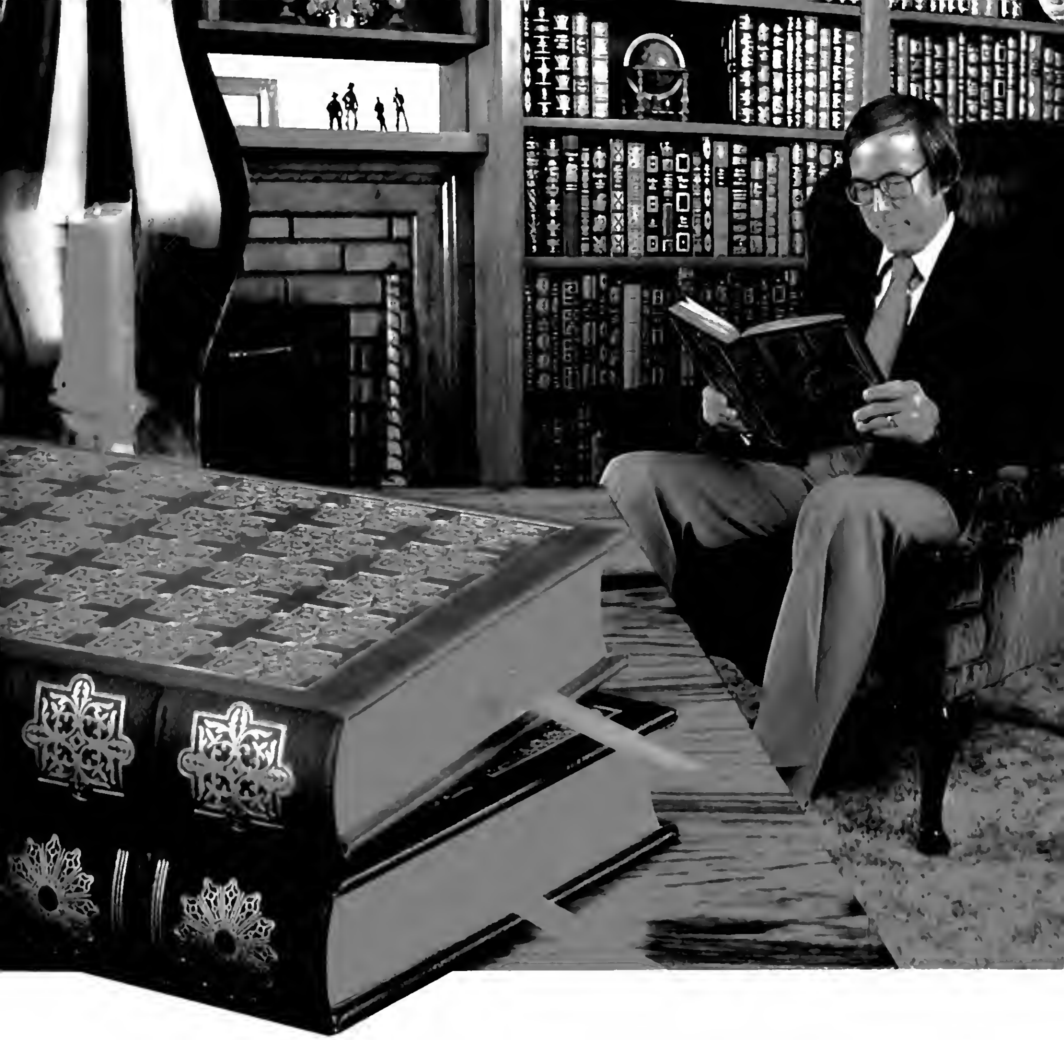

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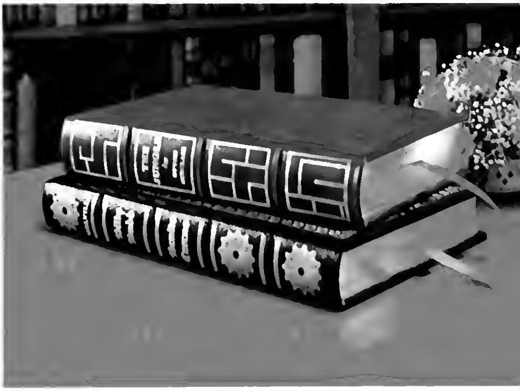

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Forest Renewal in India

Although firewood and timber are scarce throughout the subcontinent, one state at least is alleviating its wood shortage

by Erik Eckholm

Of the world's most desperately deprived people, the 800 million or so living in what has been termed "absolute poverty," one-third are in India. Likewise, a good share of those suffering the effects of severe firewood and timber scarcity and of land degradation live in India. What happens with Indian forestry, while of interest and relevance to outsiders, is important above all in its own right, for as India's landscape goes, so goes the welfare of hundreds of millions of people.

Within the last decade, the need for radical shifts in forestry practices has been widely recognized in India. The country's technically skilled, highly professional forest service has, it is now apparent, been both a blessing and a curse. Its patient, conservative management of those forest reserves it could protect from the encroachment of farmers has prevented the sort of rapacious, shortsighted commercial logging that is depleting forests in many third world countries. But in the face of steadily growing demand, the extremely low wood output from India's reserves has resulted in soaring lumber prices and a critical shortage of pulp. Meanwhile, the scattered trees of

Rajesh Bedi

Trees are vanishing from the Indian countryside. Even in the state of Madhya Pradesh, known for its forests, some areas are denuded. In the state's Chambral Valley, village women carry off all the firewood they can find.


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Wood is a basic need in rural India, along with food, clothing, and shelter. Wherever it is available, wood is the prime fuel source for cooking food.

Marilyn Silverstone, Magnum Photos

the Indian countryside, which supply the daily forest-product needs of most of India's 650 million people, are vanishing. Firewood, fodder, and small timber are becoming ever more scarce and expensive, dung burning is more prevalent, and the environmental problems associated with land denudation are becoming more acute. At the same time, the forest reserves themselves are being depleted by the spillover effects of the spreading rural wood famine.

The urgent need for the reform of Indian forestry was spelled out in national policy documents in 1972 and 1973. Culminating years of study, the reports of the National Commission on Agriculture called for new programs of "production forestry"—the application of modern, intensive timber management in forest reserves to boost commercial timber output—and "social forestry"—the growing of trees outside the reserves to meet the small-scale needs of the people, to enhance the environment, and to provide aesthetic improvements and recreation. As with much government business in India, the national government could lay out policy directions and promise financial assistance to the states, but it was up to the twenty-one individual state governments to implement the new strategies.

In the last half decade, production forestry has, in fact, gotten off to a fairly good start in many parts of the country. While requiring far-reaching changes in timber-management practices, production forestry, unlike social forestry, has not required major reforms in the nature of the forester's role and relations with people. Not surprisingly, the social forestry program is, by comparison, still fumbling on a nationwide basis. Many of India's states have done precious little to carry out the ambitious community forestry plans described in 1973.

Official perception of the importance of the activities now labeled social forestry is by no means new in India. Back in 1952, the young nation devised a national forest policy that stressed the need to promote village forestry. To instill a "tree-consciousness" among people, an annual festival of trees called Vanamahotsava was encouraged. Subsequent five-year plans have invariably called for the spread of village woodlots and the planting of trees among farm fields. Yet "unfortunately, even after a lapse of twenty-six years, the desired objectives have not been achieved," observes a leading Indian forester. "The natural resources needed for the practice of social forestry—land and manpower—are available in adequate quantities. What is lacking is the mechanism and the methodology to marry the two."

Social forestry has never received the funding necessary to get it off to a strong start, but lack of money has not been the chief obstacle to success. Nor have suitable technologies been absent. If there is one thing Indian foresters know how to do well, it is how to raise trees. But institutions have not been created to encourage foresters to transcend their traditionally limited role as guardians of the reserves, and means have not been established to secure the cooperation of the people in solving what all recognize as critical problems. The constraints on community forestry in India have been less technological and economic than sociological and bureaucratic.

The nature and consequences of these institutional failures are readily apparent in Madhya Pradesh, a large state in the country's central highlands. Madhya Pradesh is known for its rich forests and for its high proportion of people called tribals—economically backward, frequently exploited ethnic

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groups that make up a fifth of the statewide population. The tribals share the lowest rungs of the socioeconomic ladder with the untouchables, who constitute 15 percent of the state's residents. With a total population of close to fifty million, Madhya Pradesh could, like several of India's states, stand alone as one of the world's twenty most populous countries.

Thirty-six percent of Madhya Pradesh's area is labeled forest reserve: with more trees than any other state, Madhya Pradesh exports considerable timber to less fortunate regions. Madhya Pradesh's forests serve the neighboring states in more subtle ways, too, for they protect the headwaters of five major river systems. A colonial inspector general of forests once remarked that if Madhya Pradesh were to cut down its strategic forests "it would actually do more harm to other states than to its own."

Because the state has not been able to organize its bureaucracy and people to halt the timber losses, its natural forest endowment is being steadily eaten away as human and equally large livestock populations climb. Already, according to a recent field survey, the annual cutting of firewood and timber exceeds new growth in twenty-six of the state's forty-five districts. If current trends persist, sixteen of these deficit districts will be virtually bereft of trees within twenty years; more than half the state will be devoid of trees within fifty years.

These statistics of emerging scarcity take on meaning in light of the pervasive roles that wood and other forest products play in the daily lives of Madhya Pradesh's residents. A thoughtful forester, who has been waging a rather lonely struggle to get social forestry under way in Madhya Pradesh, writes: "It is often said that the three basic human needs are food, clothing, and shelter. One cannot think of food and shelter without wood, which is a more basic need. In fact, it may be truthfully said of an average villager of the state that he is still in the 'wood age.'"

Cultivation in the state relies mainly on wooden plows, and produce is transported in wooden bullock carts. Houses are built of wood and mud or bamboo and thatch. Wood is required for a host of other purposes—fencing, furniture, implements and utensils, handicrafts. Above all, as the forester put it, "wood, a marvelous, God-given means of storing solar energy, is also required to cook food with. . . . The production of food grains without the means to cook them and make them edible would appear to be a halfhearted attempt at achieving freedom from hunger."

Nonwood forest products also contribute to village life. Perhaps most important of these are the grass and leaves that help sustain the state's cattle, which in turn pull plows and carts, supply milk and fertilizer, and supply cooking fuel where wood is not available. Traditional medicines, foods, and assorted barks and leaves are also extracted from the forests. And then there are the environmental services that the forests provide free of charge—enhancing agricultural production and the general quality of life.

Even in urban areas, some of them

These pilgrims gathered for a religious ceremony use the scarce supply of wood not only as fuel to cook their food but also to warm themselves around a make-do fire.

A tree plantation in the state of Gujarat is symbolic of the forest department's program to encourage private individuals to plant trees in addition to crops on their own land.

far from any forests worthy of the name, the social importance of trees intrudes on one's consciousness. By truck, by bullock cart, by bicycle, by human head, loads of firewood and poles—used for construction—constantly stream into the state's capital city, Bhopal. Dotted all about the city are dealers selling poles, sawed lumber, and firewood; stacks of wood are ubiquitous. No splinter or scrap of bark is left unused; whole businesses are founded on sawdust or on dust generated by charcoal handling, both of which are compressed into valuable pellets. One enterprising man, having noticed that discarded batteries burn well, makes a living selling a mixture of corroded, crushed batteries and sawdust, which is used for cooking.

A few years ago, as wood gathering nearby became more difficult, firewood prices in Bhopal began to climb steeply, so here, as in many other Indian cities, the government itself entered the firewood trade. The state forest department hauls in wood, often over long distances, and markets it through a network of dealers with the price set to cover only operating expenses. Five years ago, 220 pounds (100 kilograms) of wood—at most twenty days' worth for a family of five—sold in private shops for about seven rupees (a little under a dollar). As the price rose into the teens, the burden on the poor—some of whom must get by on a few hundred rupees a year—became unbearable, and illegal tree cutting, already widespread, reached epidemic proportions. As of late 1978, the government-supplied shops were selling wood at twelve rupees per 220 pounds, and because of the competition, private shops were selling it at fourteen rupees. Forest officials figure the price would have risen above twenty rupees had their operation not been established.

Long ago, the Indian government, to prevent widespread starvation, set up "fair-price shops" that sell food at subsidized rates to the poorest of the poor. Now the government is being forced in many areas to supply subsidized firewood so that people will be able to cook their food. Clearly the government's entry into the firewood business has helped relieve immediate economic distress, but unless the distribution of firewood is linked with commensurate reforestation efforts, the government's policy is a sure formula for even greater future distress. "We're drawing on our forest capital in order to meet today's needs. This can't go on forever," warns a forest officer of the Bhopal district.

The fuel, small timber, and other forest products collected on a day-to-day basis by villagers have a collective name, *nistar*. An individual's access to forestlands for *nistar* collection is a hallowed right that no government could remove. Unfortunately, this right is not accompanied by a sense of obligation to raise new trees. The consequences are not hard to guess. Originally each village had specific areas allotted for *nistar* requirements and livestock grazing; forest reserves were to be off-limits. But overuse has gradually reduced the productive *nistar* forest areas to scrubland. Soil erosion has set in, the topsoil has washed off, and in many parts of the state a point of no return has been reached. As village lands become useless, the forest department inevitably has to relent and allow *nistar* collection in the forest reserves.

In theory, small-scale wood gathering could be compatible with healthy forest growth. Villagers are supposed to gather only deadwood, and only a headload at a time, for personal use.

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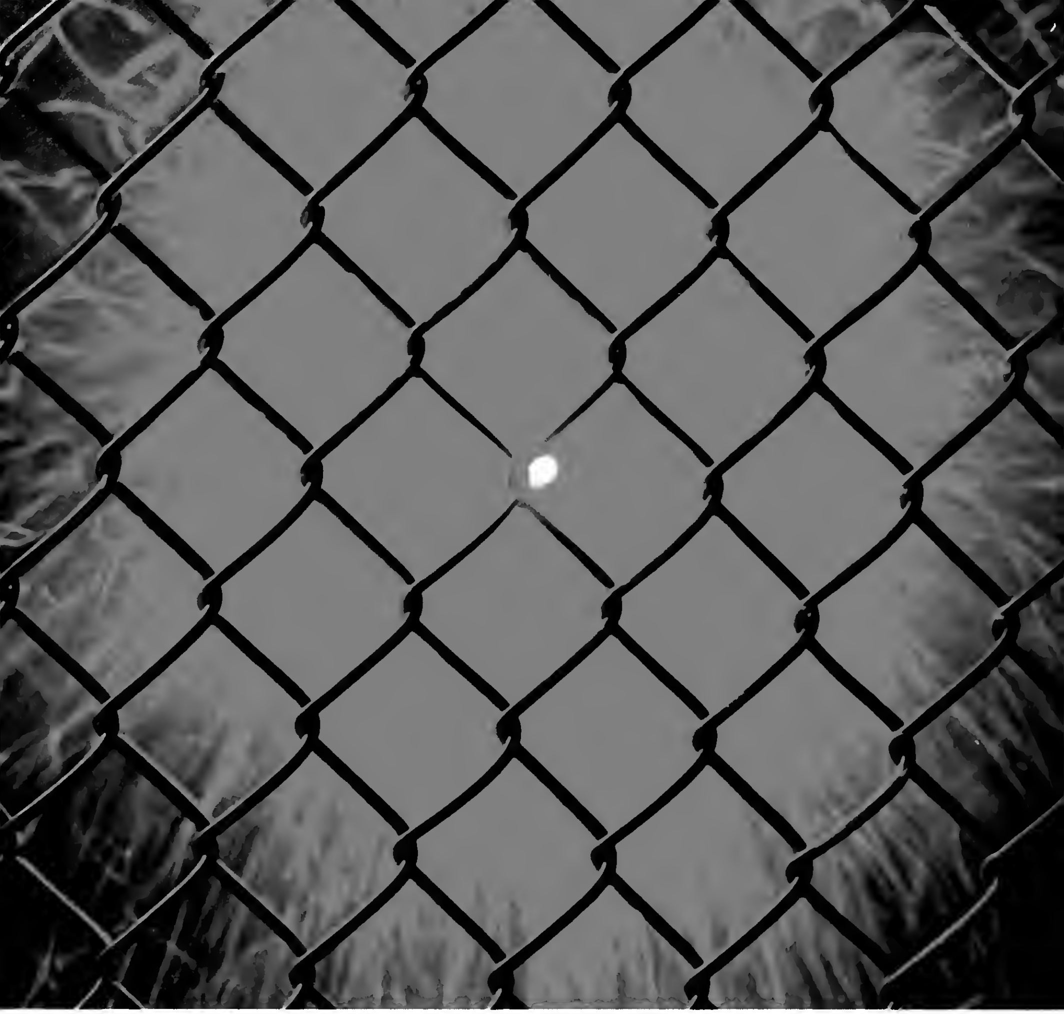

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Here and there in the reserves, however, are signs that "deadwood" is being actively manufactured: trees with their bark girdled and trees axed outright, drying for later collection. Live trees are transformed into "personal" headloads of deadwood, which then end up being sold in a nearby town. Large regions of forest reserve in the more densely populated parts of Madhya Pradesh, and particularly near towns where commercial wood markets exist, are thus, like the *nistar* areas, being reduced to scrubland.

Forest officers and guards in the field are fighting a losing battle to enforce the law. The frustration built into their jobs shows on their faces as they talk. "You can't spend all your time arresting and fining every petty offender cutting green wood, especially when you see they're just trying to keep their families alive. But you can't sit idly by while the forest for which you are responsible is destroyed," lamented one forest official as we drove near Bhopal.

We were in a skeletal landscape of hacked and felled trees. We had earlier passed by several wood pilferers without stopping, but this scene, a few hectares of woodland almost totally cut over, was too much for the forester to ignore. Some stick huts in the center of the devastation held the culprits, a few destitute tribal families. Their cutting had been so concentrated and brazen, the forester said, because they hoped to plant crops on this land. When such encroachers get crops into the ground and homes built, they can appeal to politicians for sympathy and sometimes get permission to stay. Other squatters, caught by foresters before they have a chance to sink roots, are arrested or evicted.

The foresters are caught in the middle of this sad melodrama. To fulfill their responsibilities as foresters they must eject all encroachers, but political pressures from above often argue otherwise. And then there are the "offenders," pitifully poor people who are there not out of evil intent but because the system offers them no legal way to make a decent living. The official with whom I was riding had been compassionately describing the plight of the poor as we drove up to the devastated area. This time his features hardened as he accosted the landless encroachers and questioned them about their activities. Later he sent out a squad of rangers to drive them out of the reserve.

Stick by stick, Madhya Pradesh's forest wealth is dissipating. But the continued degradation of the state's land, and hence of its people, is not inevitable. Although the current losses are striking, the potential for building a sustainable forestry system in the state is equally striking. Around every village lie extensive grazing grounds that have no chance to grow grass and sizable, currently useless areas unfortunately labeled "wastelands" in government statistics. Properly protected, such areas could support thick stands of fast-growing trees and grasses. Traces of the social cooperation that is the prerequisite of successful woodlots are also visible. Near some villages stand patches of high grass, unprotected by any fence, yet left ungrazed by mutual consent in order to keep a fodder reserve for the dry season. The land is there and the foresters know the needed planting techniques; once a constellation of forces appears that can break the current immobility, village forestry may catch on fast. The same social organization that could bring about reforestation could also facilitate introduction of more efficient cooking stoves and the replacement of free grazing with stall feeding.

Right next door and to the southwest of Madhya Pradesh, the state of Gujarat, facing the same problems, is proving that community forestry *can* work in India. In Gujarat new forestry institutions and attitudes are being hammered out and some progress can be seen. The state is one of the most tree-poor regions in India—indeed, in the world. Less than 10 percent of Gujarat is labeled forest reserve, and only half that area contains commercially exploitable timber. Mainly semiarid, the state includes just 0.06 hectares of forest reserve for each of its 31 million residents, less than half of India's extremely low national average. Nevertheless, the state from which Mahatma Gandhi emerged to lead India to independence is now providing national leadership in social forestry.

Fuel-wood consumption in Gujarat in 1975 was 4.8 million tons, but only 200,000 tons were officially extracted from reserves; the remainder was either imported from other states (including Madhya Pradesh), gleaned from increasingly barren community lands, or poached from reserves. During the last fifteen years, the market price of firewood in Gujarat has climbed faster than the market prices of electricity and oil. Special government depots sell firewood cheaply to the poorest of the poor, but dung burning is also widespread. So costly are poles and firewood in Gujarat that, according to the forest department, "fruit and fodder trees . . . are cut down in the prime of life from agricultural lands to make easy and quick money." Fodder—the production and use of which are inte-

Where longstanding land abuse and rapid population growth have rendered districts bereft of trees, villagers must resort to dried cow dung for their cooking fuel.

grally related to forestry problems in India—is also incredibly scarce. When drought grips Gujarat, as it often does, the always sparse grasslands become totally inadequate to sustain the livestock population, and the state government must import thousands of tons of grass.

Bleak as Gujarat's forestry outlook is, the state does have certain advantages. Although 40 percent of its rural population scratches by below the official "poverty line," which is calculated to provide only bare subsistence, the state's literacy rate of 36 percent is one of India's highest. And its government is reputed to be one of the most efficiently administered in India. Acutely disadvantaged groups, tribals and untouchables, make up one-fourth of the total population, and one-fifth of all rural households are headed by landless farm laborers. But the state is renowned for its successful cooperative movements—especially the huge Amul dairy cooperative, which has improved the lot of poorer farmers in particular, and the forest laborers cooperative societies, which have bettered the position of what had been some of the world's worst-off workers. In general, Gujarat's population displays a widespread civic spirit; pride in the state's role as the birthplace of the Gandhian movement is deeply felt.

Latent advantages are, however, not transformed into concrete results without imaginative people who are able to break with the ways of the past. In Gujarati forestry, this critical leadership was provided by M.K. Dalvi, the former state chief conservator of forests, whom many now call "the father of social forestry in Gujarat." In 1969, Dalvi recalls, the state forest service decided to try a new approach that depended on personal involvement and education of the public on the importance of forestry.

The first part of what has evolved into a many-dimensioned program was the establishment of plantations alongside roads and canal banks. The state owns these strips of land and has carried out the planting on them, but each stretch of plantation is linked to a nearby community that has grass-cutting rights among the trees, helps protect the saplings, and shares in the profits of the operation. This plantation program marked a critical psychological turning point; it demonstrated that trees could grow on what had been desolate land and that the activities of the forest department, long perceived as primarily a policing agency, could benefit the public. By 1978, more than 3,500 of the state's 10,500 miles of roads and canals were lined with new forests, and each year trees are planted along another 950 miles.

A second important goal of the Gujarati forest department is to encourage private groups and individuals in the cities, and farmers in the countryside, to plant trees on available lands. So anxious is the department to make Gujarat green—for aesthetic and environmental as well as economic reasons—that it provides seedlings and advice free of charge to anyone who will take them. Students in particular have been mobilized to plant seedlings, and the state's cities are becoming more pleasant as trees spring up around schools, government agencies, and stores. But the really big potential for private commercial forestry exists on farms.

So far, commercial forestry has been integrated into farming mainly among richer farmers with larger landholdings. Some of these farmers have abandoned traditional crops altogether to grow trees, usually fast-growing eucalyptus hybrids, on their lands. One has planted seventy-three of the seventy-seven hectares of irrigated land under his control with eucalyptus trees. Watered and fertilized, the trees grow incredibly fast; his best specimen reached a height of eighty-two feet in four and a half years.

Harvested at five years, the trees immediately send up shoots from their stumps, so that several consecutive harvests are possible before replanting is necessary. The trunks of the trees are sold for construction, while the branches, bark, and leaves are sold for fuel. Grass fodder and date palms are sometimes planted between the rows. The above-mentioned farmer is making more profit per hectare growing trees than he previously did growing long-staple cotton, and he claims to be hiring more labor, with the work spread throughout the year rather than concentrated during the frenetic agricultural harvest period.

Farms of this sort have amply demonstrated the biological and commercial potentials of tree farming in Gujarat, but they hardly constitute social forestry. The forest department is now considering a program of subsidies to help smaller farmers plant trees on the eroding, marginal portions of their farms. Many farmers could raise their incomes and better protect soil quality through forestry, but they are too poor to wait even a few years for the cash returns on such an investment. Special credit and aid measures will be necessary to tide them over the initial years if private tree growing is to spread among poorer farmers.

The core of social forestry in Gujarat is the village plantation scheme. Back in 1973, following the initial success of the roadside and canal-bank programs, foresters began visiting villages to discuss the possible establishment of plantations on some of their communal lands. The foresters proposed to the *panchayats*, the elected councils that govern each village, that they set aside a minimum of four hectares for this purpose. The department would supply seedlings and pay poorer villagers to do the land preparation and planting; in turn, the villages would guarantee to protect the areas from grazing and unauthorized wood gathering. The villages would have the right to harvest grass and fruit from the plantations free of charge. When it came time to harvest the trees, the councils and forest department would split the proceeds. Harvested firewood and timber would be sold through government-run depots at prices well below those of the marketplace.

By 1978, after several years spent in convincing initially suspicious councils that the proposed plantation plan would be of benefit, nearly 3,000 of the state's 18,000 villages had established woodlots through the program. Each year more agree to enter the scheme, and many have decided to devote more than the minimum four hectares to forestry. Some villages have even given precious irrigation water over to tree growing.

One reason for the spreading popularity of this village program is the quick return it generates. It is commonly thought that forestry takes too long to be attractive to, or feasible for, poor villagers, but this notion has been disproved in Gujarat. After one year of protection from livestock, grass that can be harvested by hand usually springs up on the plantation lands. Suddenly the villagers begin to receive economic benefits from an area that was formerly worthless. In the second year, some fruit trees begin to produce as well. And even in the absence of irrigation, most of the tree species planted grow quickly enough to convey an obvious economic message to nearby residents.

Another potentially significant component of the state's social forestry

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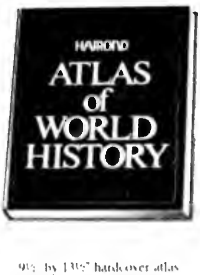

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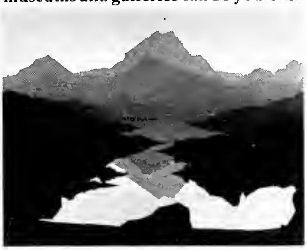

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program is just now getting under way. Large reserve forest areas have been severely degraded by pilferage and the encroachment of landless drifters, much like those I had seen being evicted from the forest in Madhya Pradesh. Efforts to establish plantations in these reserve areas have been consistently frustrated. The state is now planning an innovative measure that may provide a secure and reasonable income to those now undermining reforestation and at the same time create forest resources. Through what foresters are calling the "social security" program, landless families will be placed in charge of an area, initially 2.5 hectares, and paid year-round wages to plant seedlings and protect them to maturity. The family will be assigned an additional area for planting each year until the first year's trees are ready for harvest—a period of ten or more years—at which time the family will receive 20 percent of the proceeds from the sale of the timber. Thus currently rootless people will receive a steady income and have a personal stake in the quality of the forests they tend.

As practiced to date, social forestry in Gujarat has led to neither the self-sustaining community involvement nor the transformation of social relations that it can, in theory, entail. The village woodlot program is clearly an operation of the state forest service, rather than a self-help scheme. The use of elected councils as the main filters through which village opinions are expressed and benefits are distributed is enough in itself to keep the program from rocking the socioeconomic boat; the tendency of these bodies to be dominated by economic elites and political factions is legendary. Nevertheless, as the local forestry program continues, the villagers are gaining experience in its management, and officials hope eventually to give village institutions more control over its operations. And to the extent that procedures are set up whereby new wealth is created on communal lands and shared equitably among villagers, the absolute well-being of the poor will be improved. The proposed social security program, in particular, will help some landless people accumulate assets and gain more control over their lives.

Even under existing conditions, the degree of cooperation by Gujarat's villagers has been phenomenal. The best evidence of this lies in the absence of strong fencing around both roadside

and village woodlots. The trenches, live cactuses, or thorny shrubs now used to demarcate the forests would scarcely slow down a person intent on stealing some fodder or fuel. "These barriers are there more for psychological than for physical reasons," says one official, "and the amazing lack of stealing is an indication of the people's support for the social forestry program." The barbed wire often deemed essential by foresters working in less cooperative environments would be prohibitively expensive in India—and in most developing countries, for that matter. Its absence in Gujarat bodes well for the future of community forestry.

Despite its successes, Gujarat's social forestry program would be further enhanced by a broader approach to the problems it is addressing. The state's firewood supplies are so inadequate, and unused land of decent quality is so rare, that fuel scarcity will never be eliminated by tree planting alone. Alternative energy sources and wood conservation are also needed; ideally, those introducing forestry to a village would simultaneously promote these. As the program is expanded with World Bank assistance, Gujarat officials plan to integrate household demonstrations of efficient cooking stoves into the village forestry program, but in general wood conservation has not received anything approaching the priority attention the situation demands. (A more efficient means of cremation, which reduces the wood used in funerals from the usual 900 to 1,100 pounds to just about 350 pounds is already being pushed by foresters and a private social organization in Gujarat. In a country of 650 million, where virtually all the dead are cremated, the new crematorium could save a significant amount of wood and also reduce family funeral expenses.)

Whatever the flaws of social forestry in Gujarat, they do not negate the central fact that this state has reversed the tide of forest depletion. In forestry, things are improving rather than sliding downhill. Success, of course, breeds more success. Far from being dispirited, as are those fighting land degradation in so many places, Gujarat's foresters seem imbued with a spirit of achievement and hope. If the pride and pleasure with which they describe their programs is any measure, the practice of successful community forestry must be one of the world's more satisfying occupations. □

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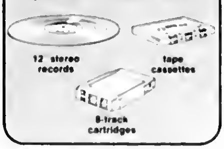

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The Glorious Bird

A bald eagle named Old Abe was carried into battle during the Civil War

by Gerald Carson

From time immemorial, birds have been held in particular esteem as omens and as totems, especially the eagle, whose soaring flights were interpreted in Homer's *Odyssey* as signs of events yet to come in human affairs. And the eagle has been the symbol of Saint John the Evangelist, of imperial Rome, and of other proud empires that have since risen and passed away.

In our own American annals, no individual member of the zoological world can rival Old Abe, the Wisconsin Civil War eagle, in the nation's affections, although one might get an argument in favor of Jumbo, P.T. Barnum's celebrated elephant, or of a magnificent, shaggy, American bull bison whose name may or may not have been Black Diamond and whose home was probably, but not certainly, New York's Central Park Zoo. The bison was real, all right, but the high regard in which he was held was due in part to an unfair advantage: he represented money since his profile appeared on the reverse of the "buffalo" nickel.

But on to our eagle, who was, after all, designated our national bird in 1782. Early in 1861, at sugar-making time, a Chippewa Indian called Chief Sky captured a young bald eagle (*Haliaeetus leucocephalus*) at the headwaters of the Flambeau River near the line between Wisconsin's Ashland and Pierce counties. Finding a large, tub-like nest of mud and sticks in a tall pine, the Indian felled the tree amid the screams and menaces of the parent birds. A few weeks later, when the Flambeau band moved south to dispose of baskets, furs, and moccasins, Chief Sky carried the young bird to Eagle Point. There a farmer named Dan McCann acquired the bird, now nearly grown and handsome, for a bushel of corn. McCann, in turn, took the eagle to Eau Claire, where members of the Eau Claire Badgers, later Company C of the Eighth Wisconsin Volunteer Infantry, chipped in to buy the appealing raptor for $5.00, although a variant account says the price was $2.50. The captain of the company gave the bird the felicitous name Old Abe in compliment to President Abraham Lincoln.

Old Abe was formally sworn into the service of the United States in a ceremony that included placing red, white, and blue ribbons around his graceful neck and a rosette of the same colors on his breast. A new rank, eagle bearer, was created, and a soldier was detailed to carry the eagle beside the regimental colors on a special perch. Little flags made by two patriotic ladies were placed on each side when the regiment was on the march. The bearer wore a belt with a socket to receive the butt end of the staff. The pole was about five feet long, which made it possible to carry the eagle three feet above the heads of the men. This, a member of Company C recalled, "made him quite conspicuous."

Early in September 1861, the Eau Claire Eagles (formerly Badgers) boarded the steamer *Stella Whipple* with banners flying. People shouted and wept, as they said farewell to the young recruits departing for the war. The little steamer carried the soldiers downriver to the Mississippi where it was made fast to the levee at La Crosse. There the First Wisconsin Battery boomed a salute. As the spectators shouted greetings, the war eagle was

State Historical Society of Wisconsin

carried proudly above the line of march, the color bearer and the eagle bearer heading the column—the colors on the right, eagle on the left. At this time an offer for Old Abe, the first of many, was made and refused. The bird could not be bought, even for $200 on the barrelhead.

The company traveled by rail from La Crosse to Madison, to join the regiment forming at Camp Randall, moving briskly at the quickstep past the capitol building to the gates of the camp. At that moment Old Abe became a celebrity. As the men of the Seventh Wisconsin lined up on each side of the entrance to greet the new men of the Eighth, and the band played "Yankee Doodle," the majestic bird cast an eye on the American flag floating above him, seized its starry folds in his beak, and spread his wings to their full extent—six and a half feet. It was an irresistible *tableau vivant.* The crowds went wild when they grasped the symbolism—our national bird, the bird of freedom, aligning the natural world with the Union cause. Omen indeed!

At the time, Old Abe weighed about ten and a half pounds. His breast was broad and heavy; his body symmetrical with a white tail, well rounded. He had a large, well-developed head, bright yellow legs, and talons sharp as grappling irons. The plumage was brown with hints of gold, the greater part of the neck a snowy white, the iris of the eyes a brilliant straw color, the pupils a piercing black. For this splendid creature a new, more elaborate, round wooden perch was designed. At each end were clusters of golden arrows, and underneath the crossbar, a shield with painted stars and stripes was attached and slightly slanted in recognition of the biological necessities of eagles (and for the comfort of eagle bearers). Below, there appeared the legend, "8th Reg.W.V." A leather ring was attached to one of the eagle's legs, with a stout cord about twenty feet long. On a march or during a battle, the eagle bearer took in the slack,

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giving the bird a free play of about three feet.

At Saint Louis, where the Eighth arrived on the 14th of October, the boys—and they were boys—were addressed by dignitaries including Simeon Cameron, secretary of war, and General George H. Thomas. The Union ladies gave the handkerchief salute, the crowds were enthusiastic. In the excitement of the day, Old Abe broke loose from his moorings and had to be coaxed back to his perch. And the offering price for him rose to $500, without response. Incidentally, the war eagle, who could easily have returned to his wild state on numerous occasions, never failed to come back after being at liberty, although often at a time of his own choosing.

The Eighth Wisconsin was assigned to the western theater of war, where it did railroad guard duty, manned rifle pits, and engaged in a number of skirmishes. On various occasions it took heavy casualties, being under heavy fire at the battles of Farmington and Corinth; the capture of Island No. 10; the assault on Jackson, Mississippi; the siege of Vicksburg. It took part in the Red River expedition, and later, toward the end of its period of enlistment, in the two-day battle at Nashville in 1864. The eagle was in the thick of it all, carried high on all marches, present at every battle in which the Eighth was engaged, spreading his wings when he heard the bugle calls, and screaming through the smoke and roar of battle. At Corinth, according to one version of the story, Old Abe's cord was cut by a bullet and the war eagle soared high above the battle, even dropping rocks upon the rebel forces. This may be carrying anthropomorphism pretty far, but it is a fact that the phenomena of war—the drums and rattle of musketry and the roar of cannon—did excite the bird, and the rest is, well, a matter of the will to believe. At any rate, the eagle undoubtedly lifted up the spirits of a whole regiment. And he survived. Once he wavered in the sky, but a solicitous examination showed that only a few tail feathers had been shot away.

Like all soldiers, Old Abe found that in war there is more waiting than fighting. When in quarters, Abe was allowed a good deal of freedom. He amused himself catching bugs, fishing in a creek, tipping over water pails, stealing baseballs, sneaking into the sutler's tent for dainties. Old Abe never forgot a grudge and punished any soldier foolish enough to "get fresh" with him. In general he was as independent as a hog on ice. Abe disliked dogs, except for Frank, the regimental dog, who brought in rabbits, squirrels, rats, and mice; as a gourmet, however, his preference was for Confederate chicken, which seemed to agree with his constitution remarkably well. Once Abe discovered a cup of peach brandy and swallowed it, thus rounding out his military experience by finding out what it was like to be drunk.

As his fame spread, tributes to Old Abe came from high personages. On one occasion a group of generals dashed past, among them General U.S. Grant, who doffed his hat in salute to the eagle; on another, General William T. Sherman, noticing the élan of the Eighth Wisconsin, remarked: "You are worthy to carry the American eagle." Once the Eighth got into trouble over the eagle; an entire line of march was held up when Old Abe could not be found. The Eighth had been ordered to report at once to brigade headquarters on the Memphis road. The bugler sounded the assembly; officers barked "fall in." But the boys did not march. An aide-de-camp came to repeat the order. Still the regiment did not move. The ranks were watching the eagle keeper out in a field trying to get Old Abe to come down out of the sky. After this was accomplished, the formation moved off smartly with the long, swinging stride characteristic of western men. Before they appeared at headquarters, however, a third peremptory order had gone out from the general of brigade. Then the following colloquoy took place between the general and the regimental commander.

"Colonel, did you not receive orders to report here with your command some time ago?"

"Yes, sir," replied the colonel.

"Then why did you not report promptly—you have kept the column waiting nearly an hour."

"General," said the colonel, "Old Abe was off when your unexpected orders were received, and the boys of the Eighth would not march without their eagle."

"I don't blame them. Under the circumstances," said the old general, "damned if I would have marched either."

Members of the color guard of the Eighth Wisconsin Volunteer Infantry pose with Old Abe in Vicksburg, Mississippi, July 1863.

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A furlough home enabled the war eagle to celebrate the Fourth of July, 1864, in Chippewa Falls, and the *Wisconsin State Journal* noticed that he had put on weight and "acquired dignity and ease of bearing . . . the impersonation of haughty defiance." The eagle participated in his final battle at Hurricane Creek, Mississippi, in the late summer of 1864. At the time he was mustered out of service, P.T. Barnum, the great showman of the age, made an unsuccessful bid of $20,000 for the sacred bird. Governor Lewis received the bald eagle as an honored charge of the state. A large, airy cage in a special room was prepared for Old Abe in the capitol building, and he was given life tenancy in his quarters and the right to draw rations in perpetuity. On nice summer days, Abe, with his attendant, enjoyed the freedom of the capitol grounds under the shade of venerable oak trees.

But Old Abe's career was not over; he still had public duties to perform as a civilian. He was in demand as a star feature of sanitary fairs (to raise money for medical care for soldiers) and encampments of the Grand Army of the Republic, where the boys cheered, marched, ate hardtack and sowbelly, sang Civil War marching songs, and cheered for Old Abe—while he cheered back, after his fashion. On these occasions, devoted to nostalgia and charity, Abe lent a photograph or a tail feather (worth $10) to raise funds for sick and wounded veterans. At a great fair in Chicago, for example, in 1865, the eagle raised about $16,000. In fact, in a souvenir book written about Old Abe, the author explained in a note that the volume was "prepared to furnish a means whereby a few veterans, maimed in the service of their country, might turn an honest penny."

When the Republican Party nominated No-Surrender Grant for president in 1868, the *Chicago Tribune* said that the veteran eagle flapped his wings in approbation, which caused the enthusiastic eagle-biographer to head a chapter "Old Abe Nominates Grant for President." With fame came portraiture, not only by the camera but also in sculpture. Abe sat (or perched?) for Leonard W. Volk, the sculptor who preserved Lincoln and Stephen A. Douglas in marble. Working the clay in life-size form, Volk approximated Old Abe's famous pose of 1861, wings partly spread, holding the folds of the flag in his beak. Unfortunately, we know this work of art only by inadequate description; the plaster mold perished in the great Chicago fire of 1871.

Eighteen-hundred and seventy-six—the centennial of American independence. It goes without saying that Old Abe attended the great Centennial Exhibition in Philadelphia, the first of our great World's Fairs in the United States. Abe was one of the chief attractions during that centennial summer, feted especially on Wisconsin Day. Standing on the national escutcheon, supported on a lofty pole, he behaved with the dignity of a hero of some forty-two battles and skirmishes. Crowds were always at hand, and the bird surveyed the animated scene around him, a historian of the exposition wrote, "with an air of royal majesty."

Old Abe's death and apotheosis were spectacular, not to say, Wagnerian, and fully consistent with his extraordinary life. He didn't peg out until March 1881, when a paint-and-oil smudge fire in the capitol basement created a suffocating volume of oily smoke. The eagle was rescued but never recovered from smoke inhalation, refused all food, and died on March 26 in the arms of his keeper. A gracefully posed image of the bird was preserved by the art of taxidermy and displayed in the Capitol War Museum until February 1904. Then another fire swept through much of the museum, this time destroying all that remained of Old Abe. "The vision ends," wrote an amateur poet, "and we will leave him there,/And trust in God with faith and earnest prayer/That Victory's dream be fully realized,/And all the world be nobly eagleized!"

Old Abe's memory endures. Today on state highway 178, approximately eight miles northeast of Chippewa Falls and the Chippewa River, a historical marker commemorates the "glorious bird" at a wayside that is part of the old McCann farm, and an oil portrait by an unknown artist hangs in the state capitol in Madison, Wisconsin. It perpetuates a legend, yes, not of the Paul Bunyan school of unnatural natural history, such as the Black Hodag, *Bovinis spiritualis*, subject of many tall tales, but an affectionate legend, mostly true, based upon verifiable fact.

Gerald Carson is author of the book Men, Beasts and Gods: A History of Cruelty and Kindness to Animals *(Scribner paperback).*

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Our Greatest Evolutionary Step

It happened some five million years ago, before the human brain enlarged

May I quote from my April 1976 column in order to recant an argument advanced in the same article:

New and significant prehuman fossils have been unearthed with such unrelenting frequency in recent years that the fate of any lecture notes can only be described with the watchword of a fundamentally irrational economy—planned obsolescence. Each year, when the topic comes up in my courses, I simply open my old folder and dump the contents into the nearest circular file. And here we go again.

In that column I reported Mary Leakey's discovery (at Laetoli, thirty miles south of Olduvai Gorge in Tanzania) of the oldest known hominid fossils—teeth and jaws 3.35 to 3.75 million years old. Mary Leakey suggested (and so far as I know, still believes) that these remains should be classified in our genus, *Homo*. I therefore argued that the conventional evolutionary sequence leading from small-brained but fully erect *Australopithecus* to larger-brained *Homo* might have to be reassessed, and that the australopithecines might represent a side branch of the human evolutionary tree.

Early this year, newspapers blazed with reports of a new species—more ancient in time and more primitive in appearance than any other hominid fossil—*Australopithecus afarensis*, so named by Don Johanson and Tim White. Could any two claims possibly be more different—Mary Leakey's argument that the oldest hominids belong to our own genus, *Homo*, and Johanson and White's decision to name a new species because the oldest hominids possess a set of apelike features that are shared by no other fossil hominid. Johanson and White must have discovered some new and fundamentally different bones. Not at all. Leakey and Johanson and White are arguing about the same bones. We are witnessing a debate about the interpretation of specimens, not a new discovery.

Johanson worked in the Afar region of Ethiopia from 1972 to 1977 and unearthed an outstanding series of hominid remains. The Afar specimens are 2.9 to 3.3 million years old. Premier among them is the skeleton of an australopithecine named Lucy. She is nearly 40 percent complete—much more than we have ever possessed for any individual from these early days of our history. (Most hominid fossils, even though they serve as a basis for endless speculation and elaborate storytelling, are fragments of jaws and scraps of skulls.)

Johanson and White argue that the Afar specimens and Mary Leakey's Laetoli fossils are identical in form and belong to the same species. They also point out that the Afar and Laetoli bones and teeth represent everything we know about hominids exceeding 2.5 million years in age—all the other African specimens are younger. Finally, they claim that the teeth and skull pieces of these old remains share a set of features absent in later fossils and reminiscent of apes. Thus, they assign the Laetoli and Afar remains to a new species, *A. afarensis*.

The debate is just beginning to warm up, but three opinions have already been vented. Some anthropologists, pointing to different features, regard the Afar and Laetoli specimens as members of our own genus, *Homo*. Others accept Johanson and White's conclusion that these older fossils are closer to the later south and east African *Australopithecus* than to *Homo*. But they deny a difference sufficient to warrant a new species and prefer to include the Afar and Laetoli fossils within the species *A. africanus*, originally named for south African specimens in the 1920s. Still others agree with Johanson and White that the Afar and Laetoli fossils deserve a new name.

As a rank anatomical amateur, my opinion is worth next to nothing. Yet I must say that if a picture is worth all the words of this column (or only half of them if you follow the traditional equation of 1 for 1,000), the palate of the Afar hominid certainly says "ape" to me. (I must also confess that the designation of *A. afarensis* supports several of my favorite prejudices. Johanson and White emphasize that the Afar and Laetoli specimens span a million years but are virtually identical. I have often defended a belief that species do not alter much during the lengthy period of their success and that most evolutionary change accumulates during very rapid events of splitting from ancestral stocks. Moreover, since I depicted human evolution as a bush rather than a ladder in the April 1976 column, the more species the merrier. Johanson and White do, however, accept far more gradualism than I would support for later human evolution.)

Amidst all this argument about skulls, teeth, and taxonomic placement, another and far more interesting feature of the Afar remains has not been disputed. Lucy's pelvis and leg bones clearly show that *A. afarensis* walked as erect as you or I. This fact has been prominently reported by the press, but in a very misleading way. The newspapers have conveyed, almost unanimously, the idea that previous orthodoxy had viewed the evolution of larger brains and upright postures as a gradual transition in tandem, perhaps with brains leading the way, from pea-brained quadrupeds to stooping half brains to fully erect, big-brained *Homo*. The *New York Times* writes (January 1979): "The evolution of bipedalism was thought to have been a gradual process involving intermediate forerunners of modern human

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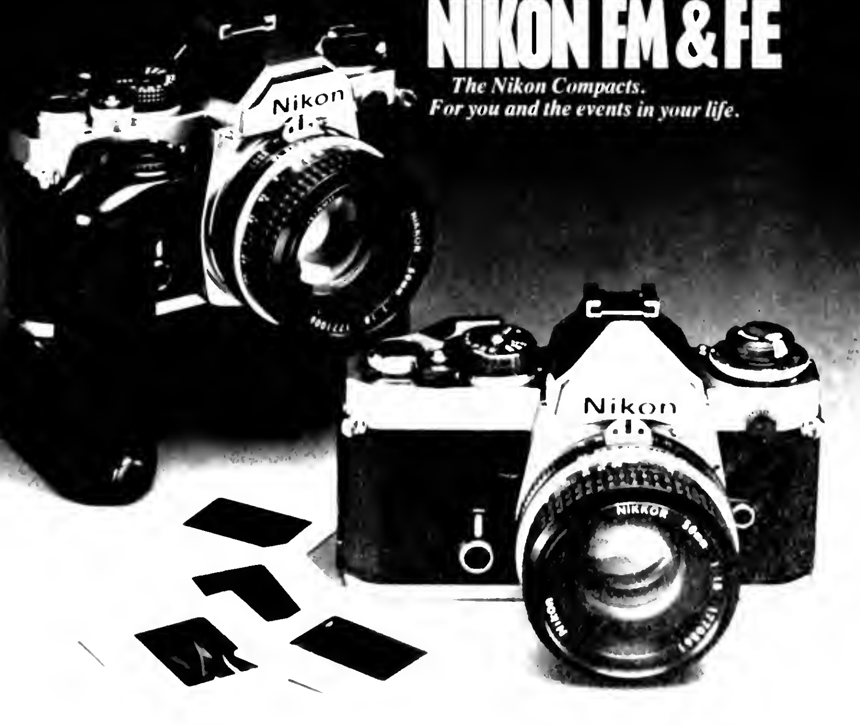

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beings that were stooped, shuffle-gaited 'ape-men,' creatures more intelligent than apes but not as intelligent as modern human beings." Absolutely false, at least for the past fifty years of our knowledge.

We have known since australopithecines were discovered in the 1920s that these hominids had relatively small brains and fully erect posture. (*A. africanus* has a brain about one-third the volume of ours and a completely upright gait. A correction for its small body size does not remove the large discrepancy between its brain and ours.) This anomaly of small brain and upright posture has been a major issue in the literature for decades and wins a prominent place in all important texts.

Thus, the designation of *A. afarensis* does not establish the historical primacy of upright posture over large brains. But it does, in conjunction with two other ideas, suggest something very novel and exciting, something curiously missing from the press reports or buried amidst misinformation about the primacy of upright posture. *A. afarensis* is important because it teaches us that perfected upright gait had already been achieved nearly four million years ago. Lucy's pelvic structure indicates bipedal posture for the Afar remains, while the remarkable footprints just discovered at Laetoli provide another kind of more direct evidence. The later south and east African australopithecines do not extend back much further than two and a half million years. We have thus added nearly one and a half million years to the history of fully upright posture.

To explain why this addition is so important, I must break the narrative and move to the opposite end of biology—from fossils of whole animals to molecules. During the past fifteen years, students of molecular evolution have accumulated a storehouse of data on the amino acid sequences of similar enzymes and proteins in a wide variety of organisms. This information has generated a surprising result. If we take pairs of species with securely dated times of divergence from a common ancestor in the fossil record, we find that the number of amino acid differences correlates remarkably well with time since the split—the longer that two lineages have been separate, the more the molecular difference. This regularity has led to the establishment of a molecular clock to predict times of divergence for pairs of species without good fossil evidence of ancestry. To be sure, the clock does not beat with the regularity of an expensive watch—it has been called a "sloppy clock" by one of its leading supporters—but it has rarely gone completely haywire.

Darwinians were generally surprised by the clock's regularity because natural selection should work at markedly varying rates in different lineages at different times: very rapidly in complex forms adapting to rapidly changing environments, very slowly in stable, well-adapted populations. If natural selection is the primary cause of genetic change in populations, then we should not expect a good correlation between genetic change and time unless rates of selection remain fairly constant—as they should not by the argument stated above. Darwinians have escaped the anomaly by arguing that irregularities in the rate of selection smooth out over long periods of time. Selection might be intense for a few generations and virtually absent for a time thereafter, but the net change averaged over long periods could still be regular. But Darwinians have also been forced to face the possibility that regularity of the molecular clock reflects an evolutionary process not mediated by natural selection, the random fixation of neutral mutations. (I must defer this "hot" topic to another time and more space.)

In any case, the measurement of amino acid differences between humans and living African great apes (gorillas and chimpanzees) led to the most surprising result of all. We are virtually identical for genes that have been studied despite our pronounced morphological differences. The average difference in amino acid sequences between humans and African apes is less than one percent (0.8 percent to be precise)—corresponding to a mere five million years since divergence from a common ancestor on the molecular clock. Allowing for the slop, Allan Wilson and Vincent Sarich, the Berkeley scientists who uncovered this anomaly, will accept six million years, but not much more. In short, if the clock is valid, *A. afarensis* is pushing very hard at the theoretical limit of hominid ancestry.

Until recently, anthropologists tended to dismiss the clock, arguing that hominids provided a genuine exception to an admitted rule. They based their skepticism about the molecular clock upon an animal called *Ramapith-*

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ecus, an African and Asian fossil known mainly from jaw fragments and ranging back to fourteen million years in age. Many anthropologists claimed that *Ramapithecus* could be placed on our side of the ape-human split—that, in other words, the divergence between hominids and apes occurred more than fourteen million years ago. But this view, based on a series of technical arguments about teeth and their proportions, has been weakening of late. Some of the strongest supporters of *Ramapithecus* as a hominid are now prepared to reassess it as an ape or as a creature near to the common ancestry of ape and human but still before the actual split. The molecular clock has been right too often to cast it aside for some tentative arguments about fragments of jaws. (I now expect to lose a $10 bet I made with Allan Wilson a few years back. He generously gave me seven million years as a maximum for the oldest ape-human common ancestor, but I held out for more. And while I'm not shelling out yet, I don't really expect to collect.)

We may now put together three points to suggest a major reorientation in views about human evolution: the age and upright posture of *A. afarensis*, the ape-human split on the molecular clock, and the dethroning of *Ramapithecus* as a hominid.

We have never been able to get away from a brain-centered view of human evolution, although it has never represented more than a powerful cultural prejudice imposed upon nature. Early evolutionists argued that enlargement of the brain must have preceded any major alteration of our bodily frame. But *A. africanus*, upright and small brained, ended that conceit in the 1920s, as predicted by a number of astute evolutionists and philosophers, from Ernst Haeckel to Friedrich Engels. Nevertheless, "cerebral primacy," as I like to call it, still held on in altered form. Evolutionists granted the historical primacy of upright posture but conjectured that it arose at a leisurely pace and that the real discontinuity—the leap that made us fully human—occurred much later when, in an unprecedented burst of evolutionary speed, our brains tripled in size within a million years or so.

Consider the following, written ten years ago by a leading expert: "The great leap in cephalization of genus *Homo* took place within the past two million years, after some ten million years of preparatory evolution toward bipedalism, the tool-using hand, etc." Arthur Koestler has taken this view of a cerebral leap toward humanity to an unexcelled height of invalid speculation in his latest book, *Janus*. Our brain grew so fast, he argues, that the outer cerebral cortex, seat of smarts and rationality, lost control over emotive, animal centers deep within our brains. This primitive bestiality surfaces in war, murder, and other forms of mayhem.

I believe that we must reassess fundamentally the relative importance we have assigned to upright posture and increase in brain size as determinants of human evolution. We have viewed upright posture as an easily accomplished, gradual trend and increase in brain size as a surprisingly rapid discontinuity—something special both in its evolutionary mode and the magnitude of its effect. I wish to suggest a diametrically opposite view. Upright posture is the surprise, the difficult event, the rapid and fundamental reconstruction of our anatomy. The subsequent enlargement of our brain is, in anatomical terms, a secondary epiphenomenon, an easy transformation embedded in a general pattern of human evolution.

Six million years ago at most, if the molecular clock runs true (and Wilson and Sarich would prefer five), we shared our last common ancestor with gorillas and chimps. Presumably, this creature walked primarily on all fours, although it may have moved about on two legs as well, as apes and many monkeys do today. Little more than a million years later, our ancestors were as bipedal as you or I. This, not later enlargement of the brain, was the great punctuation in human evolution.

Bipedalism is no easy accomplishment. It requires a fundamental reconstruction of our anatomy, particularly of the foot and pelvis. Moreover, it represents an anatomical reconstruction outside the general pattern of human evolution. As I argued last month, through the agency of Mickey Mouse, humans are neotenic, that is, we have evolved by retaining juvenile features of our ancestors. Our large brains, small jaws, and a host of other features, ranging from distribution of bodily hair to ventral pointing of the vaginal canal, are consequences of eternal youth. But upright posture is a different phenomenon. It cannot be achieved by the "easy" route of retaining a feature already present in juvenile stages. For a baby's legs are relatively small and weak, while bipedal posture requires enlargement and strengthening of the legs.

By the time we became upright as *A. afarensis*, the game was largely over, the major alteration of architecture accomplished, the trigger of future change already set. The later enlargement of our brain was anatomically easy. We read our larger brain out of the program of our own growth, by prolonging rapid fetal growth rates to later times and preserving, as adults, the characteristic proportions of a juvenile primate skull. And we evolved this brain in concert with a host of other neotenic features, all part of a general pattern.

Yet I must end by pulling back and avoiding a fallacy of reasoning—the false equation between magnitude of effect and intensity of cause. As a pure problem in architectural reconstruction, upright posture is far-reaching and fundamental, an enlarged brain superficial and secondary. But the effect of our large brain has far outstripped the relative ease of its construction. Perhaps the most amazing thing of all is a general property of complex systems—our brain prominent among them—their capacity to translate merely quantitative changes in structure into wondrously different qualities of function.

It is now two in the morning and I'm finished. I think I'll walk over to the refrigerator and get a beer; then I'll go to sleep. Culture-bound creature that I am, the dream I will have in an hour or so when I'm supine astounds me ever so much more than the stroll I will now perform perpendicular to the floor.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

NOTE: Like the stereotypic academic who revels in flights of abstract fantasy but cannot balance his checkbook, I mixed up numerator and denominator in my April column, and reported wrongly the yearly rate of a slowdown in the earth's rotation. Two milliseconds per century is not 1/200,000 second per year, but 2/1,000 per century, or 2/100,000 per year, that is, 1/50,-000 second per year, or four times faster than I reported. Nonetheless, I trust my point stands undiminished in force. Tiny effects extended through the vastness of time have enormous accumulated impact. *S.J.G.*


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The Humpback Is Not Over the Hump

The ensnaring lines of fishing gear, and the thinning patience of cod fishermen, are posing new problems for the recovery of this endangered species

by Jon Lien and Bora Merdsoy

The North Atlantic stock of humpback whales overwinters in the Caribbean, concentrating near Silver and Navidad banks, northeast of the Dominican Republic. Here they court, mate, and calve. Because tropical waters offer little food, the whales migrate northward to the Grand Banks and coastal Newfoundland waters in early summer. In the highly productive cold water, the humpbacks feed on herring, squid, other nekton, and krill. Their main fare, however, is spawning concentrations of capelin, a small, smeltlike fish, which is also a main dietary item for codfish. The critical seasonal cycle of capelin determines the distribution and density of codfish, whales, and fishermen in Newfoundland waters. This intricate relationship between fishes, marine mammals, and humans has woven a web of trouble for the endangered humpback.

Overharvesting had brought humpback whales in the North Atlantic to the edge of extinction over half a century ago. Commercial whaling was established in Newfoundland in 1898, and by 1916 the number of humpbacks had been reduced to a few dozen animals. During the next three decades, whalers hunted other rorquals, such as fin, minke, and blue whales, with humpbacks taken only occasionally. The humpback population recovered somewhat during this period, until harvestable numbers were again reached in the late 1940s. By 1952, however, renewed whaling activity had again drastically reduced the population until only some 800 animals remained.

In 1970, worldwide stocks of humpback whales were listed as endangered, and placed under the protection of the International Whaling Commission. At present, in the North Atlantic, only a few humpbacks are taken annually by native whalers in the Caribbean and West Greenland. The last census of this population, taken in 1972, resulted in an estimate of 1,000 to 1,500 animals. Assuming a steady growth rate of 5 to 7 percent, the 1979 North Atlantic stock should consist of 1,600 to 2,400 whales. Even such a population size is by no means large enough to provide a sustainable yield adequate to warrant commercial whaling.

Over the past four years, however, there has been a substantial increase in the number of whale sightings, mostly humpbacks, off Newfoundland. These coincide with increased reports of whale-caused damage to inshore fishing gear. Cod fishing has also increased over this period; consequently, there is more gear in the water than ever before. Newfoundland's inshore fishermen are economically hard pressed by the gear damage caused by whales. In Saint Mary's Bay, on the south shore of the Avalon Peninsula, fishermen estimate that humpbacks damage 90 percent of their cod traps.

A cod trap is essentially a box whose walls and bottom are made of nets. It is supported and held stationary in the nearshore water by floats and anchors. The trap is approximately seventy-five feet in each dimension, although it may not be cubic in shape. A leader, made of netting and lines, serves to guide fish into the trap through a funnel-shaped door. The leader's dimensions depend on local bottom topography. Twice daily, fishermen empty the trap by hauling its bottom close to the surface of the water and dip-netting the fish into skiffs.

The cost of whale damage to a trap averages roughly $2,000, not including labor. One reason for this high cost is that the fishermen must remove their gear from the water during peak fishing periods for repair. Repairing a cod trap can take anywhere from one day to a week. At the peak of the cod fishing season a trap can easily catch $1,000 to $2,000 worth of fish a day. In Trinity Bay, fishermen estimate direct repair costs to gear in the summer of 1978 at $500,000. Costs of whale-caused gear damage due to downtime would be many times that figure.

The manner in which whales collide with the gear suggests that they are not attempting to get fish or bait in the trap. Typically the whales get entangled in the leader, which does not hold fish, indicating that they run into the gear accidentally. The whales' sensory capability may be inadequate to detect the leaders at sufficient distances to avoid them.

Toothed whales (odontocetes), such as porpoises, killer whales, and sperm whales, hunt and swallow prey one at a time, whereas baleen whales (mysticetes) are able to capture large numbers of prey at one time. Laboratory experiments on odontocetes, whose mode of feeding permits holding them in captivity, have determined the animals' sensory capabilities, the most sophisticated of which seems to be echolocation. Similar experiments on mysticetes are very few and results inconclu-

Entangled in the leader lines of a cod trap, a humpback may tow the gear for months. Such incidents can harm the whale and, by damaging traps, cause severe financial problems for Newfoundland fishermen.

Bora Merds

sive. Although it is a mysticete, the humpback could possess some echolocation or sensitive auditory capacities. The possibility of collisions may therefore be minimized by enhancing the acoustic properties of fishing gear with noisemakers or sound reflecting devices. Such devices, while improving detectability by the whale, must not drive commercial fish away.

The humpbacks' increased inshore activity has greatly multiplied the usual number of collisions with fishing gear. Whales injured in such collisions frequently tow entangled gear for months, and some of the injuries are fatal. Endangered or not, the humpback has seriously taxed the goodwill of the fishermen. The increase in sightings has led some of them to conclude that the whale population has risen substantially and that whaling for this species should be renewed. But before whaling is resumed, an understanding of the recent inshore increase of humpbacks is essential.

One explanation is that overfishing (by Soviet and Norwegian fleets) of the capelin, its major food species, has driven the humpback inshore in pursuit of food. In the summer of 1978 capelin were totally absent off the south coast of Newfoundland; because of the lack of capelin, codfish catches declined and humpbacks were less common. Canadian government scientists and foreign fishermen were unable to find even the previously well-defined Southeast Shoal capelin stock. In the fall of 1978 the capelin fishery conducted by the USSR deep-sea trawler fleet on and near Grey Island Bank, northeast of Newfoundland, was discontinued because of the small size of individual capelin in the catch, an indication of immaturity and excessive fishing pressure.

Fishermen and whales compete for the same resource, the capelin. When foreign nations are granted licenses to catch capelin in Canada's 200-mile economic zone, they must fish at least 25 miles offshore. Although there is a Canadian inshore fishery for export to Japan, it has only recently become important and does not take nearly the same magnitude of capelin as the offshore foreign fleet. The humpback, not subject to government restrictions, simply fishes where the best catches are obtained. Lack of capelin on the Grand Banks induces whales to feed inshore.

Not only have whale sightings increased during the last three years, local mackerel stock cycles have peaked as well, and squid have been unusually abundant in inshore waters. These fish species may also serve to attract whales. Fin and minke whale populations are believed to be in better condition than the humpbacks and increased sightings of these whales add credibility to this argument.

Fishermen point out the cessation of whaling by Canada in 1972 has made whales less timid of boats and fishing gear. Backed by evidence that a number of minor collisions with manned skiffs occurred in recent years, they are of the opinion that whales are much less fearful of, and bolder in and around, man's devices and activities. Thus, the depletion of offshore capelin, the increase in inshore mackerel and squid, and the unusual boldness of

the whales may synergistically account for the recent troublesome whale presence in inshore waters. Another possibility accounting for increased whale sightings is that there may indeed be an unexpected increase in the North Atlantic humpback population, due to increased fecundity or to immigration from other humpback stocks, say from the South Atlantic. Evidence indicates, however, that this is a highly improbable theory.

Whatever the explanation, the unignorable increase in gear and whale collisions in recent years poses a new threat to the humpback. Fishermen are being asked to bear the financial burden of a conservation policy with which they have so far concurred, but many find this situation intolerable and may unilaterally take steps to remedy it. Since the humpback is protected for the benefit of all of us, it is not unreasonable to expect that financing such protection be shared by all. Until we take steps to minimize the damage caused by whales and to insure that the costs of the damage do not rest only on the fishermen, the humpback faces a pressing threat to its existence.

Four Months of the Ground Squirrel

After emerging from their long hibernation, these high-altitude rodents use their brief time in the sun to practice infanticide, cannibalism, and altruism

by Paul W. Sherman and Martin L. Morton
photographs by George Lepp

Scene 1, spring. Snow still mantles the High Sierra of California in early May. At the summit of Tioga Pass, drifts are twelve feet deep. Suddenly, the pristine white expanse is disrupted by the appearance of a brown ground squirrel with short ears and tail. He sits quietly in the warm, dazzling sunlight, the first he has felt in eight months. In the next few days more males appear; they sit alertly near their burrows, paws folded on their chests, waiting and watching.

Scene 2, early summer. A ground squirrel creeps stealthily through meadow grasses and enters another squirrel's burrow. In seconds it emerges with a newborn pup, pink and hairless, hanging helplessly in its jaws. A quick bite to the head kills the youngster. Too late to save her offspring the mother arrives, attacks, and chases the killer away.

Scene 3, late summer. Staccato shrieks break the morning silence. Calling ground squirrels are standing on tiptoes, mouths gaping, chests heaving, and whiskers twitching. Not every individual calls, but every eye is riveted on a coyote that has just captured a mountain vole. As the predator departs, the calls die out, but the ground squirrels remain watchful, sitting stiffly at attention.

The performers in these intriguing dramas are Belding's ground squirrels (*Spermophilus beldingi*). For the last ten summers, 1969 through 1978, we and our field assistants have studied the ecology, physiology, and behavior of these animals. Now we are beginning to understand the biological significance of the scenes described above.

Belding's ground squirrels were named in 1888 by C. Hart Merriam, who received the first specimens from California ornithologist Lyman Belding. Today three subspecies are recognized. Collectively their range extends from central California north to Washington and east to central Nevada and Idaho. Historically they have been regarded mainly as agricultural pests, and until we began our studies, little was known about their natural history.

These ground squirrels are ideal study subjects for several reasons. They are large enough (eight to ten inches long and weighing seven to ten ounces) to be seen easily and they habituate readily to observers. Because they are diurnal, it is possible to observe all their aboveground activities. Finally, they are easily livetrapped and handled.

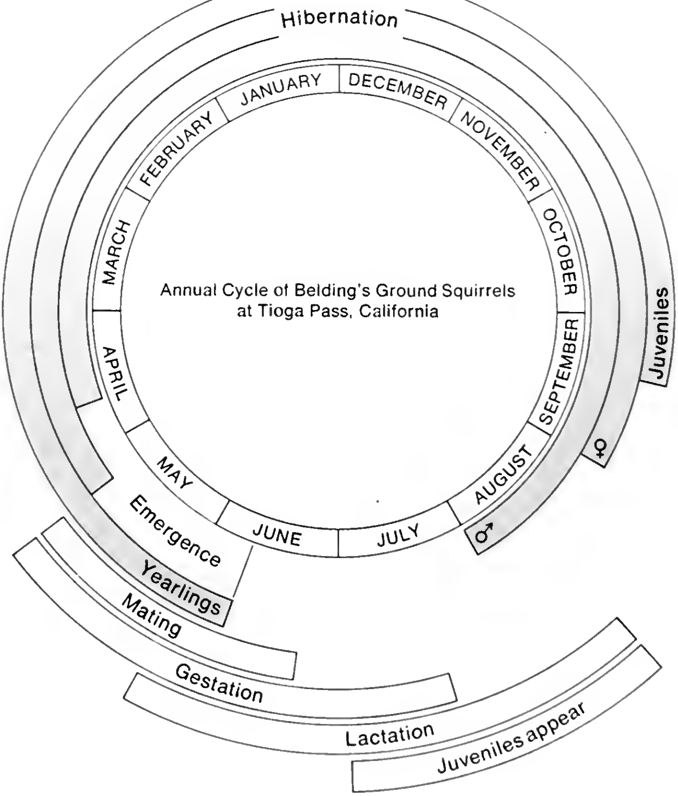
No physical features distinguish individuals, so we give ground squirrels permanent identities by attaching a tiny numbered tag to each ear. Since 1969 we have tagged 2,681 animals, including all 747 young from 162 litters. We also mark ground squirrels for easy visual identification by applying hair dye to both sides of their bodies in unique combinations of letters, numbers, and symbols. These marks do not seem to affect the animals' behavior. From 1974 to the present, we have spent 4,151 hours observing the behavior of our marked population.

Our research site is on top of Tioga

Two weaned juveniles, right, part of a larger litter, forage on the grasses around their natal burrow at Tioga Pass. Because they do not emerge until July or August (depending on spring weather conditions, which control the timing of mating), they get a late start on building up the fat deposits needed to carry them through the coming winter. As a result, they begin hibernation later than the adults. A male and female, left, engage in some precopulatory tussling. (Mature animals have been marked with hair dye to aid in identification.)

Pass, which at 9,941 feet is the highest highway pass in California. The study meadow, about a half mile long and a quarter mile wide, forms the bottom of a glacial valley; Pleistocene boulders and polished granitic outcrops give it relief. It is bordered on two sides by moraines and at the ends by Tioga Lake and Yosemite National Park. Between 250 and 300 Belding's ground squirrels live there each year. Individuals are active only during the summer, hibernating for the rest of the year (one of the longest hibernation periods of North American mammals).

Calendar dates of the ground squirrels' annual cycle vary with the duration of the winter. From 1969 to 1978, dates of spring emergence varied over six weeks, with animals emerging earliest in years of warm springs and light snowpacks. Each year adult males emerge first, tunneling through deep snow to appear one to two weeks before the females. As in scene 1, males remain near their snow holes, waiting and watching for females. They cannot feed because no vegetation is available. Females do not emerge until snow has melted off the tops of the low rises beneath which they hibernate. In contrast to males, which usually hibernate alone, females frequently overwinter in groups; often such groups are composed of close relatives. In further contrast to males, which emerge physiologically ready to reproduce, females do not become sexually receptive until four to six days after emergence and they are receptive for only three to six hours on one day each year.



Belding's ground squirrels are unusual among terrestrial sciurids in that most precopulatory behavior and copulations occur above ground. When a female comes into estrus, males congregate near her. They do not defend territories or resources of value to females; instead they follow estrous females, attempting to mate and to thwart mating attempts of rival males. Each year some males are highly polygynous, but many seldom or never mate. In 1978 for example, of twelve males under observation, three never mated and three more mated only once. The most polygynous three performed forty-six of sixty-five copulations, and the most successful male mated eighteen times with eleven different females (he alone accounted for 28 percent of all observed copulations). Heavy, old males (three or four years) win the most fights and so remain nearest to estrous females, enabling them to mate most often.

A pregnant female carries a mouthful of grass to her nesting burrow. Building a nest involves dozens of trips, which are repeated if the female needs to change the site of her burrow.

Completed copulations last ten to twelve minutes, but more than half the matings we observed were prematurely terminated by rival males. Perhaps partly as a result, most females mate more than once. Multiple mating may also enhance a female's reproductive success by assuring pregnancy and increasing the genetic diversity of her litter. Females mate an average of four times with three different males, one particularly promiscuous female copulated eleven times with eight different males. To determine which males sire litters we performed "paternity exclusion" analyses, using electrophoresis to identify polymorphic blood proteins of females, their mates, and offspring. We discovered that the majority of litters are multiply sired, that is, a mixture of full and half siblings, and that a female's first or first and second mates father most of the young.

After mating, females dig burrows and build grass-lined nests in them. Most nesting burrows are ten to fifteen feet long, one to two feet below ground, and have at least two surface openings. Females often change burrows, usually following flooding, infestations of ectoparasites, or predators' attempts to dig them out. One female changed burrows five times in a single summer. She dug three of the burrows herself and took over gopher burrows the other two times, each time she built a new nest, and in the process gathered 374 mouthfuls of dry grass.

Two males fight for sexual dominance. The combat is serious, sometimes ending in death for the loser, either directly or through the effects of injury. Winners are usually older and heavier.

Gestation lasts twenty-three to twenty-five days and the young are born in late June or early July. Each female has only one litter per season, and its size depends on maternal age: yearlings have three to four offspring; two- to five-year-olds have six to eight; and six- to eight-year-olds have three to four. Lactation lasts twenty-five to twenty-eight days, so juveniles do not appear above ground until late July or early August. Weaning occurs coincident with, or soon after, emergence from the natal burrow. By the time juveniles appear, some males have already hibernated. They are followed by females in late September. Finally, when it begins to snow, young of the year begin their first eight-month period of dormancy.

Although primarily vegetarians, Belding's ground squirrels occasionally eat insects, birds' eggs, small mammals, and carrion. They are especially fond of flower heads and seeds; indeed, the generic name for ground squirrels, *Spermophilus*, means "seed loving." Sometimes their contortions to obtain seeds are comical. When harvesting grasses many times taller than they, the animals pull the stems down paw over paw, until the prize is reached. Then they feast, lying upside down, with all four paws clutching the stalk.

As fall approaches, the animals' consumption of vegetation and seeds increases dramatically. Unlike some hibernating sciurids, Belding's ground squirrels do not cache food for the winter. Instead they store energy as fat, and before hibernation their body weight nearly doubles. At the same time, the lipid content of their bodies increases approximately fifteenfold. During hibernation they use up about three-quarters of the stored fat, leaving a small reserve, which is used after spring emergence. Thus, extensive overeating, leading to obesity, and the ability to metabolize fat during dormancy are adaptations for lengthy hibernation.

There is a sexual inequality in survivorship and longevity among Tioga Pass ground squirrels. Females usually live four to six years; at least four lived to be ten and two to be eleven. Males usually live only three to four years; the oldest male we saw was six. In addition to sexual difference in rates of senescence among polygamous creatures generally (members of the more polygamous sex die younger), injuries incurred during sexual combat contribute to differential male mortality. Fights over estrous females involve kicking, scratching, and biting and frequently result in lacerated throats, chests, and ears; broken toes, teeth, and tails; and dislocated shoulders. By the end of the mating period most males are hairless from mid-chest to mid-chin. Sometimes males are killed in fights; infected wounds hasten the demise of many more.

There are four additional mortality sources for Tioga Pass ground squirrels: weather, predators, infanticide, and automobiles (uncounted). Harsh winters are the major cause of death, with 54 to 93 percent of juveniles and 23 to 68 percent of adults perishing during hibernation. Adverse weather also causes mortality during the active season. For example, in April and May 1977 a 27-day-long storm occurred; it snowed every day and temperatures averaged well below freezing. About 60 percent of the animals active when the storm began died. They did not reenter hibernation and most presumably starved or froze after their fat reserves were exhausted.

The effects of the snowstorm illustrate dramatically the opposing selective forces that mold the ground squirrels' emergence and breeding schedule. Like other animals inhabiting regions with short and sharply defined growing seasons, they must emerge early and reproduce rapidly to insure that their young reach appropriate body size before winter. But they must also remain in hibernation long enough to avoid spring storms and food shortages. In 1976, the snowpack was light and the spring weather temperate. Early emergers had plenty to eat, and their young were unusually large when they hibernated; many of them survived their first winter. Just a year later, due to the snowstorm, late emergers were favored.

The second mortality source is predation. Each year predators kill 4 to 11 percent of our study animals. Most deaths occur at night, when coyotes, badgers, or bears dig the ground squirrels out of their burrows. Weasels and coyotes are the major diurnal predators. Cooper's hawks, red-tailed hawks, and occasionally peregrine falcons, prairie falcons, and Clark's nutcrackers also attack ground squirrels, especially the young.

Infanticide, described in scene 2, is the major cause of mortality for nursing young and is perhaps the most intriguing. From 1974 to 1978, 8 percent of all unweaned juveniles were carried out of their burrows and killed by other ground squirrels. Adult females and yearling males are the most frequent killers. We did not see females kill their offspring or those of neighbors or close relatives, and females seldom ate their victims. When all their own young are lost to predators, females often migrate to safer sites and attempt to kill young there. If successful, they settle near their victims' burrows. Killing those juveniles likely to remain in preferred areas probably reduces future nest site competition for infanticidal females.

Like females, yearling males do not kill offspring of relatives. Unlike females, however, yearling males usually eat their victims and seldom settle near their victims' burrows. Yearling males also kill and eat mice, voles, and arthropods and feed more extensively on carrion than other age and sex classes, suggesting that meat is particularly important to them. Carnivory probably enhances the growth of yearling males, thereby increasing the likelihood of overwinter survival and copulatory success in their first mating attempts as two-year-olds. Overwinter survival for yearling males and copulatory success as two-year-olds are strongly dependent on body size. We suggest that the most likely factors underlying infanticide are competition for safe breeding places (females) and competition for mates (males).

Lactating females protect their young by defending territories surrounding their burrows against intrusions by unrelated conspecifics. They

A female, probably with young in the burrow, barks out an alarm call. While more callers than noncallers are killed by predators, the alarm may give the caller's close relatives a better chance of survival.

chase nonresident females and yearling males with particular vigor. The hypothesis that thwarting infanticide is the major function of territoriality is supported by three observations: (1) territorial defense ceases when young become capable of defending themselves against conspecifics (about the time they are weaned); (2) females that lose all their young to coyotes, badgers, or bears cease defense within a few days of the loss; and (3) females with the largest territories (those able to keep marauders farthest away from their burrows) suffer the fewest losses to intraspecific predators.

Perhaps the most interesting aspect of Belding's ground squirrel demography is their pattern of dispersal, which is also asymmetric by sex. Most females are sedentary from birth, spending their lives among near and distant female relatives. Today, granddaughters and great-granddaughters of females marked when our studies began still occupy ancestral homesites. In contrast, juvenile males permanently disperse soon after weaning and establish burrows ten to twenty times farther from their natal burrows than their sisters (usually several hundred feet away). Subsequent to mating, adult males also disperse, with the most polygynous moving farthest, sometimes as far as a quarter-mile. They remain in the area to which they immigrate and attempt to mate there the following spring. Thus males seldom interact with mates or mates' offspring and they do not behave parentally; as noted earlier, they often hibernate before the young appear above ground. Postweaning dispersal by juvenile males and postmating dispersal by adult males preclude incestuous matings. Advantages of avoiding consanguineous matings may have favored the sexual differences in dispersal.

The matrilocal population structure that results from a lack of female dispersal has led to nepotism. Because we have accurate genealogical records, we can compare competition and cooperation between mothers and daughters, littermate sisters, nonlittermate sisters (offspring of the same mother but different fathers, born in different years), aunts and nieces, first cousins, and grandmothers and granddaughters. We have discovered that the first three kin pairs are highly cooperative, and that cooperation among them decreases with decreasing genetic relationship.

There are four major manifestations of nepotism among females. First, they seldom chase or fight with their close kin when establishing nest burrows, so that among close relatives, females obtain residences with a minimum expenditure of energy and little danger of injury. Second, close relatives share portions of their territories and also join together in attacking potentially predatory conspecifics. They frequently chase trespassers away from temporarily unguarded burrows of close kin. Therefore, females with close relatives as neighbors lose fewer young to infanticide than females without kin. Third, females allow close relatives access to food and shelter within their territories; distant kin and nonrelatives are never permitted such trespassing liberties.

Finally, when predators approach, some ground squirrels give alarm calls. Calling is dangerous; we have seen more callers than noncallers attacked and killed by predators. Thus calling might be termed an "altruistic" behavior. From 1974 to 1978 we witnessed 119 natural interactions between ground squirrels and terrestrial predators, as described in scene 3. On these occasions individuals risking detection and capture by calling were usually old (4 to 8+ years), lactating, resident females with living offspring and sisters. Noncallers by contrast were mostly males, nonlactating, nonresident females, and females without living relatives. These age, sex, and kinship related differences in calling tendencies, coupled with the matrilocal population structure, suggest that alarm calls function to alert relatives. Under this hypothesis, callers are trading the risk of exposure to predators for the safety and survival of dependent kin

Belding's ground squirrels apparently recognize close relatives, and juveniles seem to learn who their kin are. Such learning takes place during social play near the natal burrow in the first few days the young are above ground (just before the litters begin to mingle). We know this because recognition "errors" occasionally occurred At nightfall on their first day above ground, some juveniles entered a burrow other than their mother's (only one percent of youngsters made this mistake). The misplaced young remained in the nonfamilial burrows until their foster siblings came above ground; then they reemerged and played with the nonrelatives. The following year the misplaced youngsters cooperated with their foster mothers and sisters, with whom they had been socialized, but chased and fought with genetic kin as if they were unrelated.

Studies of the behavior of distant relatives suggest that there are limits to ground squirrel nepotism. Preliminary data indicate that aunts and nieces, first cousins, and grandmothers and granddaughters are uncooperative. They frequently chase and fight, eject each other from territories, fail to share territories or assist each other in territory defense, and refrain from giving alarm calls when they are solely in each other's presence. In short, distant relatives behave as if unrelated, and females with only distant kin as neighbors are no more successful in rearing young than females living among nonrelatives.

Why nepotism is limited to offspring, littermate sisters, and nonlittermate sisters is one of the enigmas that draws us back to Tioga Pass each spring. Perhaps distant kin cannot be recognized or else they are so rarely simultaneously alive that their cooperation has seldom been favored. In the next few years we hope to find out.

Our ten summers with Belding's ground squirrels have taught us that to begin understanding the adaptive significance of behavior, long-term studies of individuals' ecological and social environments are necessary. We are struck by the relentlessness of reproductive competition among our animals, especially the males. At the same time we are fascinated by the degree of cooperation among close female relatives. Studies of individually marked animals throughout their lifetimes are being actively pursued around the world, and important new information about the natural history of insects, fishes, amphibians, birds, and mammals is emerging. We hope such work will proliferate and receive the level of acceptance and support we have experienced. By illuminating the significance of age and kinship in particular, studies such as ours contribute to an understanding not only of ground squirrels but of the fundamental bases of social structure

Standing guard as her young emerge from their burrow, a mother is alert to such predators as coyotes and hawks. The juveniles are now fairly safe from ground squirrels bent on infanticide.

Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun, in the constellation Taurus on June 1, moves into Gemini on June 21, and into Cancer on July 20. The earliest sunrise of the year occurs on June 13 and the latest sunset on June 27. The sun arrives at the summer solstice at 6:56 P.M., EST, June 21, the longest day of the year and the first day of the Northern Hemisphere summer. On July 3, the earth reaches aphelion (Greek *apo*, "from," and *helios*, "sun"), where it will be farthest from the sun for the year—94.5 million miles.

We can expect bright moonlight during the evenings for the first third of June and July. Thereafter, the moon rises after dark, progressively later each night, and wanes. It will be seen mostly as a morning moon for about a week after midmonth. The evening moon returns as a crescent for several days at month's end. First-quarter occurs on June 2, full moon on the 10th, last-quarter on the 17th, and new moon on the 24th. In July, first-quarter is on the 2nd, full moon on the 9th, last-quarter on the 16th, and new moon on the 23rd. Apogee (moon farthest from the earth) is on June 1 and 29, July 27; perigee (moon nearest to the earth) is on June 13 and July 11.

Stars and Planets Jupiter and Saturn are still prominent evening objects during June and in early July, but both are coming to the end of their cycles. Jupiter and Mercury will be an interesting pair low in the west after sundown for three or four days before and after July 3. By mid-July, Jupiter is too low at sundown to be seen, and Saturn—though higher—is quite inconspicuous. The evening crescent moon will be near them on June 26 and 27. In the morning, Venus is still visible in June, low in the east after dawn and quite bright. But it rises too late in July. Mars, on the other hand, rises earlier each morning. Although not very bright, it improves its position daily in the morning sky. It will make an interesting group with the star Aldebaran and the crescent moon in the morning sky of July 20.

June 1–2: The moon is near Regulus and Saturn.

June 20: Venus, low in the east at dawn, is in conjunction with Aldebaran. Mars is higher to the right.

June 22: The moon occults Aldebaran in daylight.

June 26: The crescent moon is between Jupiter (higher and to the left) and Mercury (dimmer and to the right) this evening.

June 27: Jupiter and Mercury are to the right and below the moon.

June 29: Saturn is above the moon in the southwest this evening.

July 3: Mercury is at greatest easterly (to the sun's left) elongation, well placed for viewing in the west after sundown for several days.

July 10: Mars is in conjunction with Aldebaran in Taurus. The planet can easily be recognized in the familiar sky around the Pleiades.

July 16: Mercury begins retrograde (westerly) motion that takes it rapidly out of the evening sky.

July 19: Aldebaran is covered by the moon (an occultation) but below our horizon. The object to the moon's left is Mars.

July 27: The bright object near the moon tonight is Saturn.

July 29: The Delta Aquarid meteor shower (20 per hour) reaches its ill-defined and broad maximum.

July 31: Mercury is at inferior conjunction, passing the sun from left to right, and enters the morning sky.

★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 12:25 A.M. on June 15; 11:25 P.M. on June 30; 10:25 P.M. on July 15; 9:25 P.M. on July 31; and 8:25 P.M. on August 15; but it can also be used for an hour before and after those times.

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CAMELOPARDALIS
Mirfak
Caph
CEPHEUS
Polaris
LITTLE DIPPER
Kochab
URSA MAJOR
Merak
Dubhe
Phecda
Megrez
Alioth
Mizar
Alkaid
BIG DIPPER
LEO
Denebola
DRACO
CYGNUS
LYRA
Vega
Albireo
HERCULES
CORONA BOREALIS
Gemma
BOOTES
Arcturus
Rasalhague
Altair
AQUILA
OPHIUCHUS
VIRGO
Spica
June 6
July 5
LIBRA
June 10
Nunki
Antares
SCORPIUS
SAGITTARIUS
Kaus Australis
Shaula
LUPUS
CORONA AUSTRALIS

Why Food Rots

When something spoils, microbes have won out in a contest with vertebrates for food both crave

by Daniel H. Janzen

The blissful microbe that has just found a cut in a ripe strawberry has three tasks in life: first, to convert the strawberry into more of itself, that is, to propagate and increase its population; second, to convert the strawberry into compounds that will be antibiotic to other microbes; and third, to convert the strawberry into an object of disgust to the passing bird or mammal, thereby defending its food supply against competitors. In other words, spoil the strawberry. Put in different terms, you are a youngster left alone in the kitchen for fifteen seconds before your mother returns, and there are two strawberries, one fresh and one moldy, on the counter. If you pop the fresh fruit in your mouth, the microbe has won.

Ecological tradition has it that the most intense competition for anything, including food, occurs among closely related species living in the same habitat. We assume that closely related species are likely to have similar needs. But there are cases of grossly dissimilar organisms eating the same kind of food. Perhaps the most dramatic example is the competition between microbes and animals over very concentrated food sources such as ripe fruit, caches of grain, and fresh carcasses.

According to the classic explanation, putrefaction, the so-called rotting of highly desirable foods by microbes, is the battlefield that remains after competition between different species of microbes or is a spinoff of microbial extracellular digestion, during which microbes release enzymes outside their cells and then take in the results of this chemical action. Indeed, putrefaction could be both these things; in either case I believe that it is also the result of microbes' explicit efforts to render food unattractive to higher animals.

This is not a simple area of study. One beast's poison is another beast's drink, and the ecology of rotting food consumption offers some of the very best examples: wine, penicillin, and the feeding habits of vultures. Humans call a fruit spoiled if it appears unattractive; fermented if it looks agreeable. Every human culture knows an intoxicant; drinking alcohol (ethanol) is the driving ingredient of more human drink, water and milk excepted, than any other single compound. Why do yeasts make and then discard that marvelously simple little molecule, literally excreted from yeast into fruit, that has such a strong disequilibrating effect on animals? My hypothesis is that yeasts discard the molecule as soldiers "discard" bullets. A primary adaptive reason why yeasts manufacture alcohol is to render ripe fruits distasteful or unacceptable to wild vertebrates, thereby maximizing the chance that a fruit will be ignored by the very animal for which natural selection produced the fruit in the first place.

The test of this hypothesis lies in observation of the choices wild animals make when presented with naturally rotting fruits. Unfortunately, no such observations have been published. We do know that long-term alcohol consumption, in the absence of malnutrition, can produce morphological damage to the central nervous system of mice. We also know that wild animals become stupefied, perhaps drunk, after feeding on partly spoiled fruit, as in this newspaper account from Redwood City, California (February 1978).

> Drunks are being slaughtered and maimed on the Central Expressway in Mountain View in record numbers, but city and Santa Clara County road officials say they have more important things to worry about. The official disinterest is because the drunks are birds, mainly robins. The birds are eating [fermented] pyracantha berries on bushes growing along the expressway. And after a morning or afternoon of imbibing, they fly into the path of trucks and cars or right into the sides of vehicles. There are times when dead and dying birds dot the landscape. Motorists say it is almost impossible to pass the pyracantha bushes without hitting at least one bird.

Cars are not the normal predators of drunk birds, but we can reasonably assume that a wild animal with a gut full of alcohol-rich fruits is more likely to make a mistake in the face of a predator, break a limb in a fall, or fail to find a cozy place in a storm than a sharp-eyed, if hungry, animal that has passed up a dinner of fermenting fruit.

But we don't know how often birds or other vertebrate frugivores reject spoiling or fermenting fruit in the wild or even whether animals reject rotten fruit because of the taste of ethanol or of the multitude of other nasty chemical compounds made by microbes. Pyracantha berries are very small fruits; when fermented, each one contains a very small amount of alcohol, which may be too dilute for a bird to detect. Only the cumulative effect of eating many berries intoxicates a bird. In other rotting foods, the animal may be insensitive to the taste, there may be no signal of rottenness, or there may be other cues still unfamiliar to us.

A bird's hangover from eating rotten fruit may be due to other compounds besides ethanol and could be as dangerous as the drunken state—but do other animals suffer hangovers? We do know that crops of rotting fruits often remain untouched on the ground beneath fruiting trees, apparently ignored by the animals that normally eat them, and become dispersal agents of the trees' seeds. Despite our own fondness for alcoholic beverages, we usually drink them under protected circumstances—they lower our physical fitness in many ways, and we are fussy about which rotten fruits we eat.

Humans appear to be the vultures of the world of spoiling fruits; I know of

The sight of mold on a strawberry is usually enough to turn away a hungry human, and probably many birds and animals, leaving the microbe to contend with insects and other microbes for the fruit.

Thomas Page

Partly decomposed fruit does not necessarily repel birds. Every year in California, scores of birds, mainly robins, feed on fermented pyracantha berries. But. . .

no other vertebrate animal that regularly specializes in eating fermenting fruits. However, a number of insects feed on spoiling or fermenting fruits before they fall or as they lie on the ground beneath the tree. Some types of beetles and fruit flies (*Drosophila*) are the best-known examples. Resistant to alcohol, they burrow through fermenting fruits, eating the yeast. A microbe is rarely so toxic that it keeps all insects out, and besides, these insects present much less of a threat to the microbe than does a vertebrate. First, insects often just take some juices, rather than consuming the entire fruit. Second, they may be primary dispersal agents, enabling microbes to travel from rotting to uncolonized fruits. Third, their feeding activity, which makes holes and burrows in the fruit, may break down its physical structure and thereby make it a more attractive food for a microbe. The work of these insects is directly analogous to the importance of carrion-feeding insects, which break down a carcass for invading microbes. For these reasons I suspect there is great heterogeneity in the degree to which the contents of rotting fruit are toxic or repugnant to the different species of insects that feed on ripe fruit. Some microbes will repulse all; others will not discourage some. Some insects specialize in consuming microbial products; others turn away.

The function of a ripe, juicy fruit is to propagate its parent plant by enticing vertebrates that will eat it and eventually defecate, spit, or regurgitate the seeds it contains in places where new adult plants will grow. Evolution has engineered fruit color, consistency, taste, and nutrient content to be attractive, in certain amounts, to certain animals and repulsive to others. In the light of microbial consumers of ripe fruits, we have to add another dimension to the adaptive significance of a fruit's chemical traits. Theoretically, a fruit should evolve in a manner that will reduce the chances of its being so modified by microbes that it becomes unacceptable to those vertebrates that raise the parent plant species' chances of survival by dispersing seeds to appropriate places. Why do many juicy fruits have a tough skin? Why do grapes have all that tannin in their skins? Many ripe wild fruits are astringent or rich in other antimicrobial compounds. Until the 1960s, a major source of vegetable tannin for India's leather trade was the ripe fruit of *Terminalia chebula*, an Indian tree whose fallen fruits are eaten by deer, porcupines, squirrels, and other animals. High citric acid content, which renders many ripe wild fruits sour, is probably of similar biological significance. In short, odd flavors may discourage microbes but not all members of a plant's disperser coterie.

The natural food of black bread mold is not old slices of bread. *Aspergillus*, *Penicillium*, *Alternaria*, *Fusarium*, and the other genera of fungi that grow so readily on stored grain and grain products are likely professional colonists of rodents' grain caches and of ungerminated seeds and fruits in the wild. In harvesting both kinds of resource, these fungi are in intense competition with granivorous birds, rodents, and insects; not surprisingly, they are the only known species of fungi whose hyphae, a kind of rootlike structure, produce compounds that are extremely toxic to higher animals.

Aflatoxins are the compounds that receive the most attention in contemporary nutritional literature. Made by many species of *Aspergillus* and other grain-inhabiting fungi, they are among the most potent carcinogens known. Only 15 parts per billion of aflatoxin B_1 in rat diets produces a high incidence of liver tumors. A major problem for turkey farmers is contamination of feed by aflatoxin-producing fungi. Peanut farmers find that unharvested crops left in the ground for more than a month run a high risk of aflatoxin contamination. However, fungi that inhabit grain make many other objectionable compounds. Ergotism, also known as Saint Vitus' dance, is caused by alkaloids from *Claviceps purpurea* on field grains. During World War II, grains left standing in fields in central Europe over a moist winter were harvested with disastrous results for livestock and human beings; the grains had been poisoned by cladosporin and fusarigenin produced by seven species of grain-inhabiting *Fusarium* fungi. The toxins were still in the grain seven years later. From a 1976 Costa Rican newspaper comes the following report:

> More than 29,000 tons of contaminated corn were finally incinerated this week, after a long and hopeless battle to use it productively. The corn was first purchased in 1974 by the National Production Council (CNP), and upon discovery that it contained dangerous toxins, alternate uses other than sale to the public were sought. After last attempts to resell it to another country, the decision to burn the corn was finally reached several months ago.

Pharmacological literature abounds with grim tales of spoilage fungi:

> Moldy [with *Penicillium rubrum*] field corn was shelled and fed to five pigs, each weighing approximately forty pounds. Two died within four days, showing typical manifestations of the field toxicosis. The remaining three pigs refused to eat the moldy corn and subsequently were sacrificed; necropsy indicated starvation. . . . Two additional pigs were force-fed, by stomach tube, milled moldy field corn. One perished in three days, and the other in eight days; necropsy findings were indicative of the acute field toxicosis. . . . A 280-pound calf was force-fed daily six pounds of milled moldy field corn. The animal developed depression, weakness, excessive salivation, and became bloated. In addition, the animal ran short distances, would twist and turn, and work its mouth vigorously during the exertion. The animal perished on the third day during one of the seizures.

Small wonder that many farm animals will starve to death before eating moldy feed or grain. Of course, not all molds on grains produce poisonous compounds. In a test of 247 cultures of 63 *Aspergillus* species on chicks and mice, 74 cultures killed the chicks or mice and 52 more stunted the growth of one or both animals when 50 percent of the diet was moldy wheat or soybeans.

Although grain-consuming fungi make complex compounds that are very toxic to vertebrates, most bacteria, fungi, and algae are insensitive to these poisons. Therefore, these compounds probably did not evolve as a weapon in the warfare that fungi and microbes wage over high quality foods

. . . once the berries are digested, the microbes strike back. This robin is one of many inebriated birds that are killed when they fly into the path of, or collide with, oncoming vehicles.

Bob Clay

such as grain. Nevertheless, even potent antimicrobial chemicals may be valuable to their parent fungus partly because of their effects on vertebrates. To digest food, most vertebrates require aid from microflora dwelling in their guts. Hence, a potent antibiotic may be just as dangerous to a vertebrate as a compound that attacks the animal's more personal, cellular physiology. Not only compounds such as citreoviridin but also penicillin made by *Penicillium* may protect the fungus's food. A guinea pig will die if fed too much tetracycline.

In nature, a rodent cannot store a grain cache in the ground or in a rotting log without risking its contamination by spores of toxin-producing fungi. To protect its investment, the animal depends on cold or dry weather. Desert rodents probably make well-drained burrows, as much to keep their cached seeds dry and, therefore, mold free, as to keep the seeds from germinating. In the wet tropics, very few rodents make seed caches. When they do, they lose many to fungi; they often cache only large single seeds that have coats impenetrable or otherwise resistant to fungi during the normal length of time when seeds are cached. Another way in which rodents could protect caches would be to develop their own resistance to the metabolites that grain-inhabiting fungi manufacture. Compared with other animals, mice are extremely resistant to aflatoxins, although they are by no means immune. Their sensitivity to corn moldy with *Penicillium* varies widely, and natural selection could change this variation in habitats where mice have regular access to grain stores. Of the few birds that have been tested, the highly granivorous quail are the least susceptible to aflatoxins. They certainly must consume some moldy seeds in nature.

The bacterium that has found a dead mouse has much the same problem as does the yeast with its plum or a fungus with its grain cache. Putrefaction is no simple biochemical accident. The more rapidly and intensively a bacterial clone can fill a carcass with noxious compounds, the less chance that a vertebrate carnivore will take it away. The bacterial game is certainly played with compounds called amines, perhaps with other substances as well. Bacteria inside a carcass are presented with a great deal of protein. Proteins are long chains of amino acids; an amino acid with its carboxyl (–COOH) group (which makes it an acid) stripped off is an amine. Bacteria produce amines in great quantity but apparently do not use them for anything in their own metabolism. I would interpret amines as possible preemptive toxicants to vertebrates and as warning signals that there are other, less volatile toxicants in the carcass. Putrescine and cadaverine are well-known examples of the former; isoamyline and p-hydroxyphenylethylamine are examples of the latter.

There is another reason why the advertised presence of bacteria in a carcass may keep most vetebrates away. Diseases such as salmonellosis, botulism, and avian cholera that may have killed the animal could still infect carnivores that devour the carcass.

The system I have postulated above calls for the evolution of vertebrates able to effectively recognize either microbial toxins or signs of dangerous bacteria in carcasses. For example, human revulsion to microbial presence, either natural or learned, is strong. When single cell protein (bacterial cell protein) is added to human food in amounts greater than about 15–25 grams per day, it generates gastrointestinal upsets. On the other hand, I would expect certain animals to become adept at recognizing physiologically acceptable bacterial levels even when the bacteria are generating some pretty fierce signals. Some of the more fragrant cheeses are a familiar example; the animal registers the bacteria's presence, but realizes that they are not producing too much poison.

Given that bacteria frequently win their contests with ordinary carnivores for food supplies, a few exceptional carnivores have specialized in capitalizing on microbe-infected carcasses, making them their major source of food. Vultures, crows, marabou storks, hyenas, and carrion-feeding insects come immediately to mind. To feed on carrion, these animals must have an incredible gut chemistry, but it remains unstudied. Olfactory preferences are not the physiological mystery of prime interest when a hyena pulls a putrefied eland carcass out of the water and makes a meal. On the other hand, why don't the putrefaction bacteria come up with some really potent aflatoxinlike compounds that will bequeath the carcass completely to the microbial world? I suspect the answer lies in the importance of scavengers in moving putrefaction bacteria around in the world and in the importance of carrion-feeding insects in mechanically breaking down carcasses, thereby helping microbes to enter. If carcasses are protected from all multicellular consumers by fine screen cages, they decompose slowly and form mummies even in July-August temperatures in midwestern latitudes.

Hans D Dossenbach

There are a few exceptional animals whose intestinal chemistry is mysteriously resistant to putrefaction microbes, so that they can feed on rotting flesh. At right, hyenas and vultures divide spoils.

There are numerous times when humans—and, I suspect, other animals—hold their noses or put on spices and take a bite, either because the particular spoiled food is known to contain harmless mimic microbes, because humans are immune to that particular toxin, because the concentration of toxins is low, or because intoxication is desired. Ignoring signals of the remains of the microbes' presence can backfire at New Year's Eve parties or other occasions where too much booze or cheese is consumed or when unexpected microbes get into the brew; for example, *Clostridium botulinum* is a lethal contaminant of Japanese izushi, a fermented fish and vegetable dish. A lot of drunks and antibiotics users are happy that microbes fight back and produce useful materials, but the battleground is littered with chemical booby traps.

When an animal eats putrefied food of any kind, it usually risks poor nutrition, microbial infection, or injury from toxins or microbe-produced antibiotics. Of course, all these consequences may simply be the byproduct of microbes interacting with each other. But I suspect that microbes putrefy food to avoid the generally maladaptive event of having themselves and their resources eaten by larger animals. Fruits, seeds, and meat spoil because that is the way microbes compete with bigger organisms for food. □

By eating microbe-infested carcasses and excreting the remains, vultures and other scavengers play an important role in distributing putrefaction microbes around their habitat.

Fran Allan, Animals Animals

Do Honeybees Know What They Are Doing?

Some evidence suggests that these extremely clever insects learn on the job, yet they may merely be exquisitely programmed robots

by James L. Gould

The sources of the "knowledge" behind the behavior of animals have been both a fascinating question and the crux of an often bitter controversy between the two disciplines that study the subject—ethology and psychology. Ethologists have traditionally considered animals to be creatures of instinct, robots programmed by their genes, while classical psychologists envision animals as coming into the world with blank mental slates, infinitely malleable, their behavior to be shaped and directed by their environments into the most adaptive form. Nowhere is this traditional dichotomy between learning and instinct better illustrated than in the analysis of the behavior of that supremely clever animal—the honeybee.

When a forager bee leaves the hive in search of food, for example, it may fly hundreds of feet this way and that before finding a suitable patch of flowers. During the flight, it will probably have had to aim itself into the wind—perhaps considerably off its true course—to maintain a consistent flight direction. The sun, which is the bee's usual compass, may have been hidden behind a cloud or a line of trees for all or part of the bee's flight, and its position in the sky will have changed markedly over the course of the search. And yet, when the bee arrives at a food source, it is able to calculate a true compass direction and the distance back to the hive. The forager has allowed for the effect of the ever changing wind on its path; it has calculated the sun's position when it was not visible and compensated for its predetermined but variable movement to the west. What is more, back at the hive the forager will translate all these computations by means of specific linguisticlike conventions into a dance that will "tell" other bees the distance and direction of the newly discovered food. Willing recruits attend these dances, then use information gained from them to find the food for themselves.

Are honeybees creatures of instinct or learning? Ethologists can point to the bees' almost magical feats of navigation and communication as being far too complex to be learned during their short lifetimes. Yet, when examined more closely, much of this complexity disappears. Research in my laboratory at Princeton University has revealed, for example, that rather than being able to calculate the intricate motions of the sun, as had been thought, bees rely on a simple extrapolation: they expect the sun to have progressed at the same rate as the last time they checked it. When the sun disappears, bees fall back on the patterns of polarized light in the sky, which are invisible to us but

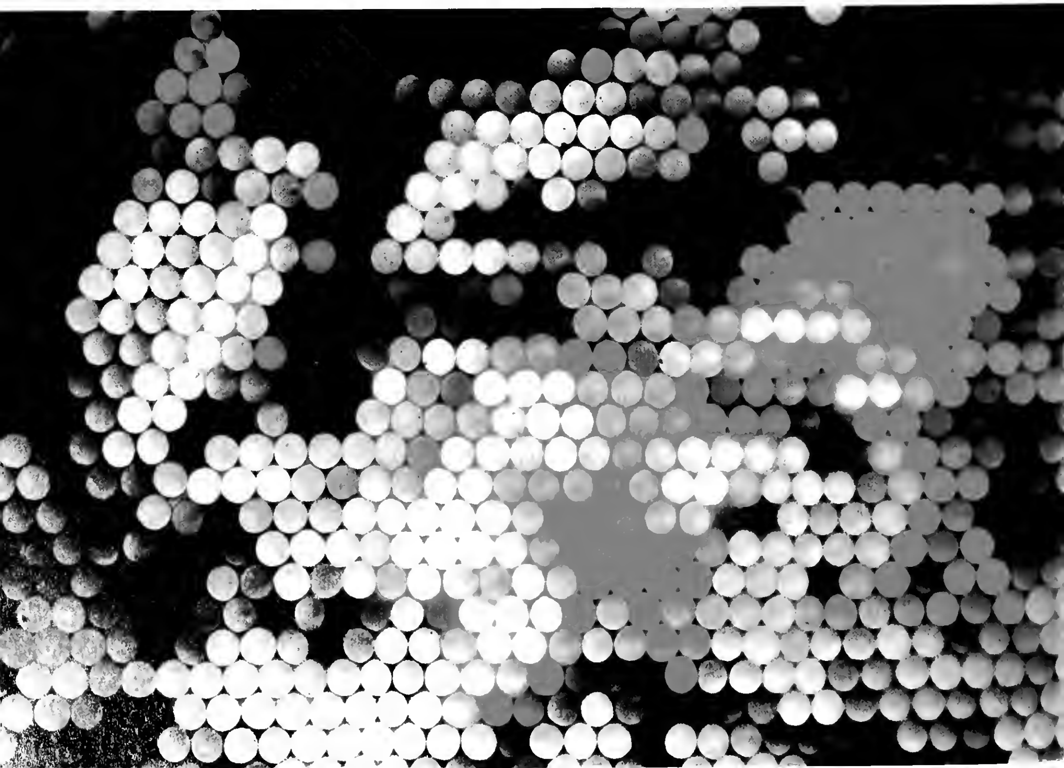
Sterling Dimmitt, National Audubon Society Collection/PR

Honeybees learn the color of a flower only during the final two seconds before landing on it; the odor only while actually on the flower; and the landmarks around it only as they fly away after feeding.

Stephen Dalton, National Audubon Society Collection/PR

By means of its dance, a forager bee "tells" recruit bees in the hive the distance to, and direction of, appropriate food sources. The recruits can then find the food for themselves.

Kenneth Lorenzen



which create for them a gigantic compass of rays.

Although the sun's location can be calculated from the information in only a small patch of blue sky, my colleague Michael Brines of Rockefeller University and I see nothing in the behavior of bees that indicates they know anything about the regular geometry of those patterns. Instead, bees seem to use a very simple system of arbitrary rules. Their ability to navigate when even the polarization patterns are obscured is a greater mystery, but it may be explained by nothing more complicated than the small magnets that my colleagues and I have recently found bees (and other animals such as homing pigeons) carry with them.

Although they may not be as complicated as they look at first, bees are still able to outperform all but very well-trained and superbly equipped human navigators, and to the best of our knowledge, their symbolic language is second only to ours in complexity. Unlike humans, bees can navigate and communicate without prior experience—those abilities are truly innate in them. Nevertheless, at every stage in their behavior, learning is essential. Foragers may calculate, substitute, and average their information in the manner of small computers, but they must learn that the sun moves (and which way), how flowers look and smell, what the hive looks like, and so on. And bees are not unique in this regard. Indeed, both instinct and learning are crucial to most insects, but even at first glance, their learning seems to be of a peculiar sort.

How well and how much do insects learn, and how does the process relate to learning in higher animals, such as birds and mammals? Insect learning seems curiously constrained and machinelike, and despite the traditional split between learning and instinct, one is tempted to call it "instinctive learning." Again the honeybee provides a compelling illustration.

More than 2,000 years ago, Aristotle noticed that on any particular foraging flight, a bee will gather food from a single kind of flower and bypass others. Clearly the bee must have learned to distinguish that one species of flower from all others. Aristotle seems not to have wondered how these diminutive creatures could do that.

Early in this century, though, Nobel laureate Karl von Frisch raised the question when he upset the prevailing view that animals in general, and insects in particular, were deaf, dumb, and virtually blind. Von Frisch reasoned that since flowers have so much to gain from bees if the insects remain faithful to one flower species, cross-pollinating the plants on each stop, and so much to lose if bees are fickle, that the colors and odors of flowers probably evolved as alluring signals for the bees to learn. Bees, von Frisch theorized, must therefore have good color vision and excellent "noses." Indeed, he was able to show that bees are able to distinguish one floral odor from among some seven hundred others and can learn any color from yellow through the greens and blues on into the ultraviolet.

So far, so good. Bees are smart enough to learn the particular colors and odors of flowers. About 1930, however, one of von Frisch's students, Elizabeth Opfinger, made the disturbing discovery that bees can learn a flower's color only as they approach the plant. This is a striking phenomenon to watch. For example, we often train bees to a feeder by catching them as they fly from the hive and then carrying them to the food. When the bees leave the food, they circle the feeder again and again as if "studying" it before flying back to the hive. Yet when they return to the feeder on their own, they have no idea of what the feeding station looks like. They search the feeder everywhere for the food, often to the great discomfort of those conducting the experiment. But after they have landed on the food only once of their own accord, they display no hesitation in finding it again.

Randolf Menzel of the Free University of Berlin has investigated in more detail how bees learn food-source color. He changed the colors of an artificial flower during the approach, landing, feeding, and departing flights of foragers and found that bees remember only the color they have seen during the final two seconds before landing. On the other hand, the bee learns the landmarks around the food only as it flies away. Indeed, if we carry a feeding bee back to the hive, it will have no recollection of the landmarks it must have seen but did not learn when approaching the feeder. It is as if bees possess a set of switches that turn color and landmark learning on and off at certain times and in certain situations. There must also be still another switch for odor, since the bee learns that only while actually *on* the flower.

The same pattern of constraints appears when foragers try to get home. On their return trip they depend on their elegant navigation systems to get close to the hive, but bees are too myopic to find the tiny hive entrance directly. For an animal whose vision is so fuzzy that a daisy more than three feet away is a formless blur, and the distance to an object can be judged only if it is no farther than six inches away, there is no choice but to depend on large landmarks near the colony.

As a result, bees have evolved a built-in program by which they learn what the hive entrance and its surrounding landmarks look like. But since the appearance of the hive and the nearby vegetation necessarily changes with time and with the seasons, bees are programmed to relearn what the hive and its environs look like on the first flight out each day. Thus a colony can be moved several miles overnight without causing any difficulty for the bees, but moving it even a few feet at midday inevitably produces swarms of confused and disoriented foragers searching frantically in the old location, even though they had flown out only a few minutes earlier from the new position.

Learning, for bees, has thus become specialized to the extent that specific cues are learned only at specific times—and then only in specific contexts. In fact, the learning programs of bees are even more specialized than that: although the insects acquire each bit of knowledge separately and at a different rate, once acquired, their knowledge forms a part of a coherent and holistic set, that is, a unit that cannot be reduced to discrete component elements.

The first hint of this possibility came about 1930 when von Frisch followed up an observation by Auguste Forel, a well-known European psychiatrist and entomologist, that the bees sharing his tea did not show up at the table until fifteen minutes or so before the scheduled hour. Von Frisch quickly confirmed Forel's guess that bees learn to

Despite their navigational feats, bees are myopic: objects appear blurred to them except when very near. Top photograph shows how a flower looks to us; simulation at bottom shows how the same flower may look in close-up to a bee.

...s L. Gould

associate a time of day with a particular food source. Since many flowers produce nectar only during specific parts of the day, bees would waste a great deal of time and energy if they did not learn this. The strategy that underlies this ability, however, can lead to some odd behavior. For example, Martin Lindauer, an ethologist at the University of Würzburg, and his students trained bees to a feeding station that contained unscented food. During one specific half hour, however, the researchers added a scent. Given a choice on subsequent days, the bees steadfastly chose unscented over scented food except immediately before and during that half hour. The bees, the feeding station, and the food remained the same, but the preference or expectation of the foragers had switched. Similar experiments have shown that time, odor, color, shape, landmarks, and location are all learned as a "set," and that if one component in the set is changed, the bee must learn the whole set all over again.

In a very real sense, then, honeybees are carefully tuned "learning machines." They learn just what they are programmed to learn, exactly when they are programmed to learn it. This seems fundamentally different from our usual view of learning in higher animals, especially in humans. We tend to suppose that the difference that we feel sets us apart from the insects is one of kind rather than degree, and that we are so different that the basic processes of bird and mammalian learning are unique. The facts, unfortunately, do not support this hope.

One of the most characteristic processes underlying mammalian learning, for example, is a phenomenon known as short-term memory. Learning is our word for what happens between the perception of information by our sense organs and the ultimate storage of that bit of information in our brains. There is no direct line between the two. Our minds first sort and filter the information. During this "short-term" phase, any shock or disturbance is likely to cause us to forget what we have just experienced. A disruption only a few minutes later, however, will have no effect. This is the source of the amnesia an accident victim experiences when he or she has no recollection of the accident or the events immediately preceding it.

Menzel has shown that bees possess the same short-term memory phase. If we shock or chill a forager within five minutes of its finding a new source of food, the bee will forget all about the food. But if we wait until ten minutes after the discovery, the knowledge will have passed into a "long-term" form and cannot easily be eradicated.

Experiments of behavioral geneticists have turned up other similarities between insect and mammalian learning, leading us to infer that learning involves a single set of basic processes that are shared throughout the animal kingdom, from *Drosophila* to humans. If this is the case, then the difference in kind that we sense separating insects from the higher animals must lie instead in the way learning is organized. Insect learning may be rigidly constrained, while learning in birds and mammals appears flexible. Again, however, the facts fail to support such a basic difference. Examples of tightly programmed learning in birds and mammals are becoming the rule rather than the exception. One simple and fascinating example is "rapid food-avoidance conditioning."

Many animals, from blue jays to garden slugs, are programmed to wait a specific length of time, which varies from species to species, after eating a

Bees learn to associate a given food source with a particular time of day. This skill leads to efficient feeding since many flowers produce nectar only at specific times.

new food to see if they become ill. If they do—even if the sickness arose from a completely independent cause—they will never eat that food again. Even more curious, each species is programmed to identify the forbidden food in the future by its own set of cues. For example, rats remember a suspect food by odor, while quail recall its color. Even though the animal can sense and, in other contexts, remember a far wider range of stimuli, it recognizes only the one or two selected by evolution as salient in this situation and studiously ignores the others.

A more complicated example of the programmed learning common to higher animals is "imprinting," a term that calls to mind a picture of Konrad Lorenz, the well-known Austrian ethologist, leading a long line of baby geese across a meadow. Young animals that have to keep up with their ever moving parents—for instance, antelope and sheep—must quickly learn to recognize those parents as individuals if they are to survive. To accomplish this, these creatures have evolved an elegant learning routine. The first task for a newborn duckling or calf is to stay with its mother in order to learn her individual appearance. To do this, ducklings are programmed to follow the first object they see moving away from them. When the object stops moving, the duckling stops too. If the object produces the call specific to the species, so much the better.

While the sight of an object moving away triggers the "following response," it is the physical act of following that starts the learning. We know this because a chick carried passively behind its mother, like a bee ferried to and from a feeder, fails to learn. In this case, the learning is further confined to a brief, species-specific "critical period" of about a day. Whatever the chick sees later is irrelevant, so that hand-reared ducklings steadfastly ignore real ducks. More recently, however, we have learned that animals with imprinting programs are not completely naïve about what their parents should look like. They are born with one or two general clues that they use if a decision between two moving objects becomes necessary—a contingency that must be very common in our crowded world. Hence, given a choice between, say, geese and people during its critical period, a duckling is programmed to pay attention to the more ducklike object.

For those of us who like to believe that nature is simple at heart, a common theme runs through these learning processes, namely, that learning is adaptively programmed so that specific contexts, recognized by an animal's neural circuitry on the basis of one or more special cues, trigger specific learning programs. The programs themselves are confined to particular critical periods—the two seconds before landing on a feeding source in the case of the bee—and to a particular subset of possible cues. Nothing is left to chance, yet all of the behavioral flexibility that learning makes possible is preserved.

To a large extent, this modified picture of "instinctive learning" is helping to bring a constructive end to the century-old debate about whether nature or nurture is the source of the adaptive behavior of animals. In general, I am inclined to conclude that animals probably *are* largely the preprogrammed robots imagined by classical ethologists, but now we know that their programming is far more elaborate than had been imagined, and that the elaborations enable them to sample their environments in particular contexts and to modify their behavior accordingly. Animals are indeed molded and shaped by their environments, but within a set of complex constraints that do not quite fit the model that classical psychologists have always maintained.

And yet, I wonder whether a theory based on a robot programmed to program itself can adequately explain all the behavior taking place around us. What about the really flexible learning

we see going on: the mastering of chance variations of environment, the solving of new problems? Could this apparent intellectual "free will" on the part of higher animals simply be an illusion created by our ignorance of how the programming has evolved to deal with complicated situations? Even with honeybees I am often tempted to explain some subtle behavior by the supposition that they know what they are doing.

For example, honeybee colonies divide every spring, and half the bees and the old queen leave to form a swarm in a nearby tree. Scouts fly out in search of suitable cavities in which to establish a new hive. The cavity must be chosen with great care since its ability to keep its occupants warm and dry during the long, cold winter is crucial to the colony's survival. Scouts return and advertise what they have found by means of the same dance used to communicate food location. At first, several potential sites may be reported, but soon, usually within a day or two, all the dances will indicate just one location. Shortly thereafter, the swarm will depart to the chosen site and set up housekeeping.

How is this important decision reached? By marking individual bees and monitoring empty hive boxes set out as "bait," Lindauer and, later, a graduate student at Harvard have been able to show that each scout makes its own evaluation based on the cavity's size, exposure to sun, dryness, freedom from drafts, and so on. Each scout advertises its find with a degree of enthusiasm that reflects the site's quality as a potential dwelling. So far, this may sound like a forager bee reporting a flower patch, but now the scout will stop and watch dances indicating other sites. It will then fly out and visit them, perhaps also reinspecting its own discovery, then return to the swarm and dance for the best one. The bee has sampled the available locations, compared them, and come to a decision. When virtually all the scouts agree —that is, when all of the dancing indicates the same spot—the swarm will then be roused and led to the chosen cavity.

Are these bees being uncharacteristically clever or is the programming simply too subtle for us to decipher easily? The small size, too numerous legs, and phylogenetic remoteness of bees from humans strongly incline me to the view that the decision-making behavior of swarm scouts could be explained as programming if we could be imaginative enough to find the clues. If the above story had been about humans or chimpanzees, however, I doubt that computerlike preprogramming would be seriously considered. But after all, bees have swarmed nearly every year for millenniums and must face this general set of problems annually.

Other examples of bee behavior are less easily explained. Honeybees, for instance, hate alfalfa because its flowers come equipped with a spring-loaded anther that when tripped gives them a nasty blow. Bumblebees, which evolved along with this flower, do not seem to mind, but once honeybees have been hit, they will assiduously avoid alfalfa. When forced to it by being put into the middle of acres of solid alfalfa—a situation that is created only by modern agriculture—individual honeybees solve the problem in the face of potential starvation by adopting one of two strategies. Either they learn to recognize tripped from untripped flowers and only visit the former, or they learn to chew through the flower from the side, taking the nectar without venturing inside and tripping the anther.

Has evolution provided bees with two contingency plans for dealing with American agriculture or have these diminutive creatures reasoned out the problem on their own? Perhaps the eeriest example that argues against bees being nothing more than elegant pieces of clockwork is what happens when we try to train them for an experiment. We begin by letting the bees find drops of sugar solution in a dish near the hive entrance. Then every few minutes, we move the dish about 25 percent farther from the hive. At the beginning, we may move the food only an inch when the distance from the hive is four inches, but later the food is transported a hundred feet or more in a single jump. Virtually every student of bees, from von Frisch on, has noticed that a time comes during training when the bees will begin to "catch on," to anticipate where the food will be next, fly that distance, and wait. I can imagine nothing about flowers that could provide a reason for evolving such a behavioral program.

Either the bees are very smart or they have been programmed with such exquisite finesse as to leave us in doubt about the source of their abilities. Donald Griffin, a distinguished zoologist at Rockefeller University, suggests in his book *The Question of Animal Awareness* that much of bee behavior is most easily explained if we assume that they are conscious beings like ourselves, although infinitely less intelligent. Experience and my anthropocentric viewpoint prejudice me against the idea that creatures so small could possibly "know" what they are doing. And yet, if we concede that even the programming of a one-milligram honeybee brain is too intricate to be distinguished easily from some sort of insect "free will," where does this leave us with regard to analyzing the sources of our own incredibly subtle and complex species-specific human behavior?

When I read that human infants emerge from the womb able to recognize and respond to human faces and to distinguish the consonant sounds of human speech; that Jean Piaget, leading authority on childhood development, has found a fixed series of culturally independent "intellectual" stages that unfold in children the world over; that Maria Montessori, pioneer in early childhood education, has identified a critical period for many types of learning in humans; and that linguist Noam Chomsky has found a common "deep structure" to all human language, I sense elements of the same pattern that has emerged in the "lower" animals, although one that is far more difficult to dissect.

What instinctual chains shackle our minds to the now irrelevant necessities of our once natural world? How do patterns of "triggers" and "critical periods"—so obvious in bees and now being found, wonderfully elaborated, all along the evolutionary continuum to humans—restrict or predispose our development? What problems in education or behavior are we failing to solve by using pre-Darwinian models that suppose that we are infinitely flexible and that our pliancy in all things persists throughout our lives? The melancholy truth is that we are blind to our own blindnesses and will continue to be so until science forges a positive link between humans and the rest of the animal world.

In the spring, bee colonies divide. The old queen and half the bees leave to form a swarm, like the one shown here, prior to establishing a new hive.

Kenneth Lorenzen

Front Door, Back Door

Despite the best-laid plans of their Victorian ancestors, Americans have taken charge of their own comings and goings

by Roger L. Welsch

There was a time—as little as seventy-five years ago—when the lane of the American farm led boldly to an open front gate, an ample front porch that virtually shouted "Welcome!" and a richly embellished front door (or even two front doors). Cedar or sycamore trees framed the straightforward approach to the farmstead; the house seemed to look out on the countryside before it, the outbuildings arrayed behind it like architectural lieutenants. Of the double doors, be they side by side or at right angles to each other, the one opened into the formal parlor, the fanciest room of the house, meant only for visiting dignitaries: the minister, the banker perhaps, or the Angel of Death, for it was here that funerals and wakes were held. The other door led into the family's front room, or living room as it was also called, where father read his farm journals, mother tatted, and the children recited their lessons. Here, too, less consequential but nonetheless honored guests were received, where they could be greeted with the studied elegance of the ideal Victorian home.

The intention was that visitors would see the family and house only in repose: the workings and processes of the unit were concealed, like those of a clock. For example, it was generally understood that the operation of cooking was to be hidden away from all guests, even those invited to dine (the kitchen might even be separate from the main building). The reluctance to share intimacy was not simply a feature of a society still characterized by a servant class; even where the wife did the cooking, people seated in the dining room did not see the steam, bustle, and clutter. A wall cabinet with doors opening into both the kitchen and the dining room permitted the fashionable housewife to place the food from

In 1903, a Nebraska farmhouse, right, boasted double front doors and an ornate porch-balcony. Deprived of a front porch and steps, a door, below, loses its intended function.

D Murphy Lincoln Nebraska
Courtesy of Nebraska State Historical Society

Nebraska State Historical Society

The Bettmann Archive

the kitchen into the wall shelves, close the kitchen side, remove her apron, enter the dining room, open the cabinet's dining room doors, and serve the food as if it had appeared magically.

But all that has changed. Front doors of old houses are often nailed or painted shut or heavy furniture has been placed in front of them, barring entrance or exit. And with good reason. In many cases, should innocent visitors try to leave by way of the front door, they would find themselves lying on the front lawn, for the porch has fallen away or been removed, leaving the front door (or doors) hanging uselessly a few feet above the ground. The front gate has rusted shut, and lilacs grow solidly across the front of the house, barring access to the yard.

The front porch, where it remains, is now regarded as an outside room of the house, where the men can retire after supper to smoke a cigar or watch the approaching storm; where children at play can escape the summer sun. It is rarely an approach to the house; a knock at a farmhouse's front door will set the dogs to barking madly and bring worried looks to the faces of the occupants.

The back door of the rural home has become so dominant as the principal entrance that in some areas of the country it has come to be called the *front* door. Many of my students, when asked about the abandonment of the front door, were startled to find that in their own minds they had not even noticed the inside of the front door of their own homes throughout the years they had lived in them. One student commented, "When I was little I always wanted to go out the front doors. I thought I was going to be killed when I tried it. My mother actually spanked me a couple of times. To this day I don't know what it was that was wrong with going out the front doors." In *My Antonia*, Willa Cather writes, "The boys escorted us to the front of the house, which I hadn't seen; in farm houses, somehow, life comes and goes by the back door."

The family enters through the kitchen door, typically by way of a small, unheated "mud porch," where work clothes, boots, tools, and guns accumulate. Farmers usually explain that the back door is more convenient to the lane road, overlooking what is often the case—the original lane has been diverted behind the house to be convenient to the back door! Some suggest that the use of the back entrance keeps mud and manure from being tracked through the front room, but this leaves the unattractive prospect of their being tracked through the kitchen. The argument that the mud room, or mud porch, was added to circumvent such problems does not

Moreover, I speculated, the traditional mode of proffering friendship was to offer food, to demonstrate trust by sharing this most vulnerable of life's activities. The symbolic function of food still pervades societies all around the world, including our own. Business is conducted over food when it might be more efficiently (but not more effectively) pursued at a desk; no major professional or social gathering is complete without a banquet where nothing happens—on the surface—that could not be accomplished more easily, quickly, and cheaply without the food; courtship invariably proceeds at the table before it advances to the couch. Ethnologists have come to agree that food frequently has far less to do with nourishment than with cultural attitudes. So I have reasoned that the opening of the kitchen to all visitors was an expression of the same

The automobile may have contributed to the eventual decline of the traditional house orientation (even for courting, it rivaled the front porch). Early vehicles can be seen at the Charles farmstead, left, which straddled the state line between New Hampshire and Maine. Below: The typical mud porch probably is the usual access to this house.

stand up because the same function could have been assigned to the front porch, had that portal been maintained as the primary entrance to the house. Most important, if the back entrance is used to accommodate the family's everyday dirt and clutter, why should guests then have to be exposed to that dirt and clutter? Why are they no longer graciously welcomed through the front door, as was clearly intended by the standard design?

In a paper delivered at the Third International Congress for Ethnographic Foodways Research in Cardiff, Wales (August 1977), I suggested that the change in door usage reflected the futility of efforts to maintain elegance in America's severe heartland—a realization that the days of servants and repose were over, that the minister was never going to come visiting, that the hope for dignity had lost out to the realities of isolation and humility.

This glass plate photograph (slightly damaged in lower right corner) was taken in Maine about 1900. It shows that there was less separation then between homes and community space, such as thoroughfares.

kind of trust as sharing the food itself.

Indeed, the very rhetoric of back-door greetings supports that contention. Upon opening the back door to greet guests, the woman (but never the man) will recite a well-practiced litany: "Excuse the mess in the kitchen. I am just in the process of [choose one or several] canning/cooking/cleaning/baking/washing dishes," all of which is evident to the visitor. The words, however, are intended not to extract indulgence from the visitor but rather to call attention to the implicit trust, not to apologize for the activities of the kitchen but to make them explicit. The hostess is saying that she shares the intimacy of food preparation with the visitor and assumes that he or she is friendly enough to accept this

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vulnerability without taking advantage of it—criticizing, laughing, or gossiping to others about the household, for example.

Increasingly, however, I feel that while the above arguments are still valid, there may be yet another basis for the reorientation of the American farmhouse. Amos Rapoport notes in his fine study *House Form and Culture* that "there have generally been two traditions of concentrated settlement. In one the whole settlement has been considered as the setting for life and the dwelling merely as a more private, enclosed and sheltered part of the living realm. In the other the dwelling has essentially been regarded as the total setting for life, and the settlement, whether village or city, as connective

tissue, almost 'waste' space to be traversed and secondary in nature."

Rapoport's concept can be easily expanded to describe the settlement or shelter within the fabric of the countryside rather than of the village. It is possible that intervening space has come to be regarded as something apart from the farmstead, and that this has affected door-usage patterns in America. Moreover, a good part of the reason for this change in attitude may have been the rise of the automobile.

Even as it made travel faster and easier, the automobile transformed our view of the countryside between towns and farmsteads from that of a pleasant and interesting space, where contemplation was as important as it was at the beginning and ending poles of travel, to that of a barrier separating the settlements, to be conquered or at least endured. Once the novelty of motoring wore off for all but a determined few, the car, it turned out, did not enhance day-to-day travel but made it a painful bore. The car goes too fast (even at twenty-five miles per hour) to permit careful and leisurely observation of the details that make travel by horse or foot pleasureful. The noises of the machine drown out whatever few sounds of the countryside manage to penetrate the glass and steel, and even smells are overwhelmed or screened. Even while moving, the wagon traveler had been able to exchange words of greeting with the driver of another wagon encountered on the road. But in the early days of the automobile, the bone-jarring velocity demanded everyone's full attention, and today's high speeds forbid all amenities.

So it was, I believe, that we lost our contact with the fabric of the countryside and transformed our farmsteads into introverted fortresses. The farmstead no longer expresses an outward relationship to the countryside but turns its back to the road, so that the house and its outbuildings now huddle in a closed circle, only rarely presenting a portal to the outside. Passers-by on the nearby road see only hedges, sealed doors, abandoned gates, and windows to rooms that can only be reached from the back of the house.

The case is most vivid with rural housing, where there is the flexibility to change completely and at will access to the home—the roads, paths, and doors. What of the urban house? Here the problem is more complex because it is rarely possible for a suburban or urban house to abandon the front door

Bill Owens

The driveways of suburban California homes, above and right, serve both pedestrians and vehicles. The principal entryway is often through the garage, which may be left open.

so completely. And yet the same cultural factors—an increasing emphasis on the kitchen as a social area and a growing aversion to the open spaces confronting the house—have affected the free-standing town or city home as much as the rural farmstead. For the older urban house, in which the kitchen was originally hidden at the rear of the floor plan, the same inversion has occurred. Salesmen, mailmen, and all strangers go to the front door, but the familiar visitor or member of the family will use the back door, which inevitably leads into the kitchen.

Indeed, my own experience has been that there is a detectable transition when the visitor knows that he or she has attained whatever degree of familiarity it is that permits entrance through the back door of a house. I have sensed myself that moment when I drive up to a house and feel that it is "time" to enter by way of the back door rather than the front. (On the other hand, for a party or more formal occasion people may well revert to using the front door, and in the event of a profoundly formal occasion, such as a funeral or wedding, almost everyone who would otherwise use the back door will instead approach the front of the house.)

New buildings may not lend themselves to the current pattern: many urban building lots are too long and narrow, and a one-story suburban house may present a two-story back with a walk-in basement. In the latter case, the back door leads not into the house proper but into the basement; few visitors would assume the familiarity of entering the house through the basement (that would be like entering through the bedroom). In the suburbs, new construction and house design have therefore responded to the contemporary preference by reversing the floor plan of the house itself. The kitchen is placed to the front so that visitors must pass by or through it to reach the more formal area of the family, or living, room, which has been pushed back into the house pattern.

As there are few designs developed nowadays specifically for rural construction, in most cases new farmhouses are simply homes designed for suburban construction but located in the countryside. The house, with its front door facing forward, usually boasts a picture window, and the kitchen is located at or near the entrance. Thus the visitor accustomed to the older farmhouses approaches the back of the house only to find there is no door there or that there is a double French door opening, not into the kitchen, but into a living room; that there is no mud room here, but a patio and barbecue grill.

Cultural pressures, however, have already begun to mold this impossible imposition of a contrary architectural structure. Increasingly, suburban houses built in the countryside are seen with the overhead doors of the attached garage wide open: the garage is becoming the mud porch, and the house door leading from the garage—usually into the kitchen—is becoming the principal access to the household. While the elegant front walk grows up in weeds, neglected, the garage entrance is used in an effort to reconstruct the desired and customary pattern. ☐

Joe Munroe, Photo Researcher

Guests and Hosts

You can dress a biologist up, but you can't take him out

I have reluctantly come to the conclusion, after much soul-searching and not a little pain, that biologists make poor dinner guests. Not that we eat with our hands, fail to bathe, or lack other social graces. The problem is that our conversations tend to encompass topics not usually included in dinner-table repartee. Just as lawyers may animatedly discuss a particularly interesting case, biologists can wax poetic about cockroaches, cannibalism, and the like.

My wife has become more or less resigned to such behavior. She was introduced to it when, in a fit of romanticism, I named a parasite after her. She had her choice of organisms: one parasitized the gall bladders of certain fishes; the other, their urinary bladders. (She picked the urinary bladder parasite—*Davisia reginae*.)

Even she, however, eventually drew the line. During dinner one night, after discoursing on *kuru* (a viral disease found among New Guineans, caused by ritual brain cannibalism) and the pearlfish (which lives in the anus of sea cucumbers), I happened to mention *Oikopleura*, a small planktonic animal that lives in mucus "houses," which also serve as filters of food material.

"That's it!" she declared. "There will be no discussion of mucus at the dinner table." Even thoroughly inured nonbiologists have their limits.

The real problem arises when we are invited to gatherings. This was made abundantly clear during a Passover Seder my wife and I recently attended. A Seder is a ceremonial dinner celebrating the escape of Moses and his flock from Egypt. I often find the conversations at these affairs to be dull, and consequently, I spend much of these evenings in a sort of stupor.

On this occasion, the conversation swung around to the kosher dietary laws. Perking up, I pointed out that the biblical prohibition against eating pork was probably not based on the prevention of trichinosis (as is commonly believed), for trichinosis, a parasitic disease contracted by eating nematode-infected pork, is only rarely found in the Middle East.

"Trichinosis," I reflected, warming to my subject, "is an interesting disease. Infected sausage, for instance, may contain as many as one hundred thousand larval worms per ounce. A million larvae could easily be ingested during a meal."

Shamelessly, my wife (who rather enjoys these performances) egged me on: "Are the worms particularly dangerous?"

"Yes, indeed," I replied, with somewhat more enthusiasm than was perhaps warranted. "The worms burrow through the intestine and travel throughout the body, boring into muscles, brains, et cetera. There is no good cure, and in Europe of the Middle Ages, whole villages might become infected—many people dying horribly."

I vaguely noticed that the gentleman across the table had stopped eating, a gefilte-fish ball poised precariously between bowl and mouth. There was no stopping me now, however. I had their attention, and I was going to keep it.

"The whole topic of parasitism is a fascinating one. Most human parasites are very well adapted to their hosts, causing few problems. Often we never know we have them. For instance, humans can have fifty-foot-long tapeworms and have few or no symptoms. You know, Jewish women were once known as a primary host for *Diphyllobothrium latum*, the 'fish tapeworm.' The larvae are found in the muscles of fish, particularly pike, which is a major constituent of gefilte fish. Women would taste partially cooked gefilte fish before the larvae had been killed, thereby becoming infected."

The man across the table slowly pushed his untouched fish aside.

My blood surging with excitement, I continued. "However, not all tapeworms are relatively innocuous. *Echinococcus granulosus* is a species that causes very large cysts, containing ten or fifteen quarts of fluid. Humans catch the worms by swallowing their eggs, which they can get from dogs. The adult worms live in the dogs' intestines, the eggs are expelled in the feces, and the dogs often have them on their tongues after licking their rear ends. People become infected when they allow dogs to kiss them."

As one, all at the table turned toward the family schnauzer, who slunk off guiltily.

The host made a game effort to rechannel the conversation, remarking on how warm the room seemed to be. But I was unstoppable.

"Americans are just not used to thinking about parasites. We don't believe we have them. Actually, there are several types that commonly infect us. For instance, some of us here have an amoeba, *Entamoeba gingivalis*, in our mouths. It does not seem to do any harm, just sort of sits about on our gumlines, waiting for an occasional white blood cell to pop out."

At the end of the table, a woman absently poured wine on the tablecloth.

"When I taught the parasitology lab," I said, savoring the memory, "the last laboratory session was feces day, when everyone brought in their own specimens. We would find various amoebae and once in a while a worm egg. People really got into it. A woman I know had contracted amoebic dysentery in Mexico. She went off the antiamoebic drugs she was taking, just to build up a large enough population to show the class."

Here I was shaken from my reverie by the white faces of my companions.

The conversation soon returned (on a somewhat subdued note) to the relative merits of chicken versus beef brisket as a main dish, but for the rest of the evening the group's enthusiasm for such topics flagged.

I, on the other hand, remained jovial. I had engaged in a brilliant discourse and broadened the horizons of my companions, while never once mentioning mucus at the dinner table.

Milton Love is a research associate in the Department of Biology at Occidental College, Los Angeles.

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Dr. J. Lawrence Pool sketching at Corinth, Discovery Tour of Greece 1979

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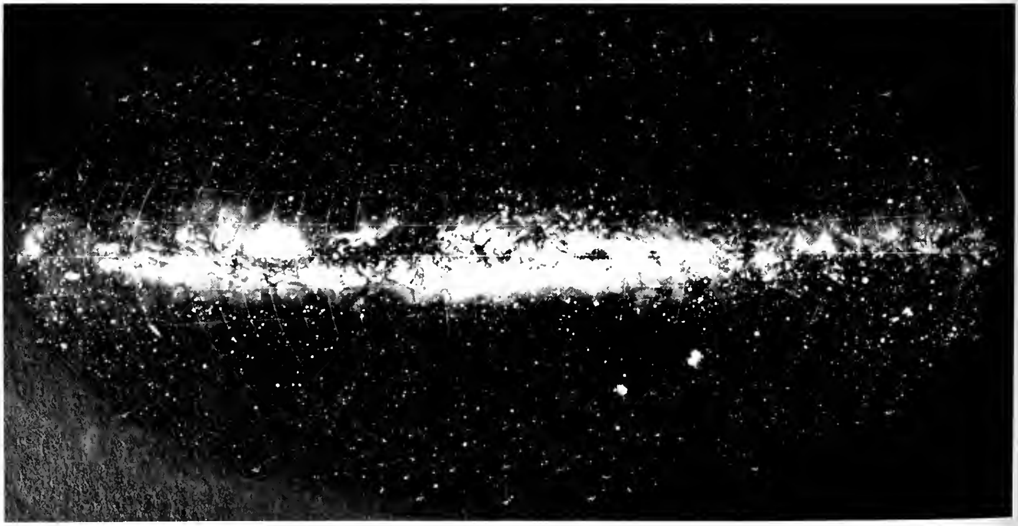
The Star Clouds of Magellan

Research on these two nearby celestial objects is adding to our information on the birth and evolution of stars

The Southern Hemisphere is far richer than the Northern Hemisphere in celestial objects of great beauty. The band of the Milky Way to the south of the celestial equator is broader, more varied, and more star studded than its northern counterpart. This is not surprising since the center of our galaxy, the Milky Way—in which our sun is but an inconspicuous star 26,000 light-years off-center—lies in the direction of the constellation of Sagittarius, next to the fine curved arch of Scorpius, well to the south of the celestial equator. The center passes overhead at latitude 30°S in Chile, Australia, and in southern Africa—all parts of the world with lovely clear night skies to tempt the astronomer.

The southernmost part of the Milky Way in the constellations of Carina, the Southern Cross, and Centaurus is especially rich and varied. Here are found the Great Nebula of Carina, the Southern Coal Sack, and the finest globular star cluster of all—Omega Centauri. Along the southern Milky Way there are many places where star birth from the interstellar medium can be seen at work. All these sights can be observed at declinations of 30° to 60° to the south of the celestial equator. Even farther to the south are the Large and Small Star Clouds of Magellan, named after the great navigator who first recorded them on his expedition around the world in 1520. These two nearby galaxies are not within reach of the major observatories of the Northern Hemisphere; they are barely visible from Hawaii. But the native populations of Australia, New Zealand, and southern Africa had noted them long before Magellan entered the picture.

The two Magellanic Clouds are glorious to behold on a clear and moonless night from a mountaintop in Chile, Australia, New Zealand, or southern Africa. They become visible to the naked eye about thirty to forty-five minutes after sunset, looking like little pieces of the Milky Way that escaped from the mainstream. The Large Cloud of Magellan is about 160,000 light-years from the sun and has an apparent diameter of 6°. The Small Cloud, some 20° to its west, is



Astronomy: Fundamentals and Frontiers by R. Jastrow and M.H. Thompson. John Wiley & Sons, Publishers

by Bart J. Bok

about 200,000 light-years from the sun, and measures approximately 2.5° across. (For reference, the apparent diameter of the moon is only half a degree.) The above distance estimates, with a possible error of the order of ± 10 percent, place the Magellanic Clouds at about one-tenth the distance from the sun and earth to the Andromeda Galaxy—the most distant object visible to the naked eye.

Astronomers in the Southern Hemisphere are in a very favorable position to study these clouds as they accompany our Milky Way, like a pair of satellites, on its travels through the universe, much as our moon travels with the earth. Both clouds are in relatively empty parts of the heavens, so observers are not distracted by excessive numbers of Milky Way foreground stars. The Large Cloud lies 33° to the south of the band of the Milky Way, the Small Cloud is 48° south of the Milky Way. Many parts of the sky are obscured by conglomerations of cosmic dust, but fortunately such "dark nebulae" are not found in the direction of the Clouds of Magellan. A clear view of both of them is thus available.

These satellite galaxies were probably formed at the same time as the

In this edge-on view of the Milky Way, the Magellanic Clouds are the two bright spots in the lower right region. The Large Cloud is about 160,000 light-years from our sun; the Small Cloud about 200,000.

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Milky Way or shortly after it. But, as we shall see, there are many indications that their stars did not develop from the available interstellar gas and dust as rapidly as did the stars in our galaxy. However, the clouds are now doing quite well in the star-building business and on a percentage basis, there are more young stars in the Magellanic Clouds than in the Milky Way. Some of the most luminous supergiant stars—outshining our sun by factors of more than 100,000 and mainly in the age range of one to ten million years—are found in these clouds.

What are some of the things that we have learned about the Magellanic Clouds in recent years? What are the prospects for the future? The most basic properties of the two clouds are that they are intrinsically bluish rather than red, owing to the large number of young, bright stars, and that much of the material they contain is interstellar gas, mostly hydrogen, not yet condensed into stars. According to the best estimates, 9 percent of the total mass of the Large Cloud and 25 percent of that of the Small Cloud is in the form of interstellar hydrogen atoms; 3 to 4 percent is a comparable estimate for the nearer parts of our Milky Way. It is therefore not surprising that the clouds possess so many cosmically young stars that are less than twenty million years old (the sun, our star, in comparison is roughly five billion years old). However, the Large Cloud has a densely populated "axis," a large bar-shaped structure, which is full of faint reddish stars, most of which are in all probability reasonably old. In addition, quite a few young red supergiant stars are strewn among their blue brother and sister stars of comparable ages.

The two clouds have a common envelope of atomic hydrogen gas, which ties them firmly together. There is also evidence of a bridge of the same gas—something like an umbilical cord left over from the birth of the Magellanic "stream"—connecting our Milky Way with the system of the Magellanic Clouds. Some young and some older groupings of stars in the form of clusters and associations are found in a bridge between the clouds. All these facts support the belief that the Magellanic Clouds are genuinely associated with our galaxy and are not unrelated galaxies sailing by the Milky Way like "ships that pass in the night."

Because the Magellanic Clouds are so close to the Milky Way, they are ideal subjects for studying the properties of intrinsically very luminous supergiant stars. The Large Cloud has been the focus of much research of this kind. Whereas there is still doubt about the precise form of the Small Cloud, the Large Cloud appears to be mostly a flat disk in which the axis perpendicular to the central plane is tilted approximately 30° with respect to the line of sight. In other words, we see the Large Cloud almost face-on.

Supergiant stars are the easiest stars to locate and study in the Large Cloud since they are so very bright. Their presence in the Large Cloud can be checked by the fact that any cloud member has a velocity of recession of about 170 miles per second, the average velocity by which the Large Cloud is receding from the section of the Milky Way that contains the sun and our planet. The few local stars belonging to our galaxy that are seen projected against the cloud hardly ever have such high velocities of recession.

Once a star's presence is established, we can determine its intrinsic brightness—as opposed to its apparent brightness—since we know that any cloud member must be about 160,000 light-years from the sun. We can then ascertain with high precision how many times brighter than our sun that star is. The most interesting supergiant stars in the Large Cloud are observed at apparent magnitudes of between 10 and 14 (apparent magnitude is the unit used for measuring the brightness of stars, with smaller numbers representing brighter stars), bright enough to enable us to obtain spectra of high quality for them and study what sorts of atoms and molecules, and in what relative abundances, are present in their atmospheres.

The most important results of such abundance studies to date are the following: Oxygen, nitrogen, and other heavier chemical elements are generally underabundant in the clouds as compared with hydrogen and carbon—a result that is shown not only by the stars but also by the gas in the nebulae of the Magellanic Clouds. And,

The Royal Observatory, Edinburgh

whereas in most spiral galaxies there are marked abundance gradients, depending upon position with respect to the galactic center, similar clear gradients are absent in the Magellanic Clouds.

These observations of the abundance gradients of the elements in spiral and related galaxies indicate that more "atom-cooking," meaning the creation of heavier elements from hydrogen by atomic transformation in the deep interiors of stars, has gone on in the central regions of such galaxies than in their thinner outer parts. The observations of atomic abundances in the Magellanic Clouds suggest that there has been relatively little atom-cooking in the clouds, and that the little that has taken place has proceeded at about the same rates in the inner and outer parts of the clouds. These results seem to support the suggestion that the Magellanic Clouds have been a bit slower than our galaxy in creating stars from the interstellar medium. Nevertheless, the clouds as now observed are building clusters and associations of stars literally before our eyes.

How does this take place? Are the processes of star formation in the two Magellanic Clouds similar to those in the nearer parts of the Milky Way? Based on current knowledge, my answer is a firm no. Some quite different processes seem to be at work in the Magellanic Clouds. Let me give two examples of the difference.

Our galaxy is rich in globular clusters, which—despite minor differences in composition—are all fairly alike. They contain many red giant stars, some faint bluish stars, especially the so-called RR Lyrae variables (used to determine the distances of star clusters from the sun), and a well-populated main sequence of reddish stars. These globular clusters are recognized as being among the oldest objects in the Milky Way; several have probable ages of ten billion years or more, at least twice the age of the sun.

Globular clusters of similar properties exist in the Magellanic Clouds,

The Large Magellanic Cloud, whose central section is shown here, contains many luminous supergiant stars. The photograph was taken at Siding Spring Observatory, Australia.

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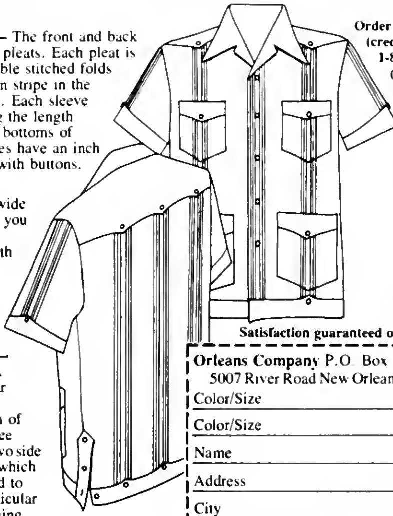

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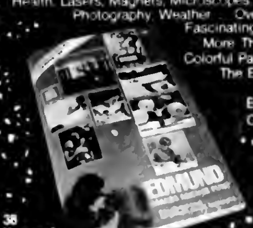

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particularly in the Large Cloud. But the clouds also contain a second variety of globularlike cluster, known as blue globulars, not found in the Milky Way. These latter clusters, often located in empty, dust-free parts of the Large Cloud, each contain about ten thousand stars and have estimated ages of a mere fifty million years or so—a small fraction of the age of the sun. Some of my colleagues who are working on Magellanic Cloud problems are zeroing in on these new types of cluster, hoping to answer questions concerning their evolution and probable future. One suggestion is that in about one hundred million years, a short cosmic time span, the blue globulars may dwindle and become inconspicuous star clusters of a variety not yet detected in the clouds or obviously present in the Milky Way. It is also suggested that the processes of star and cluster formation and evolution in our galaxy and in the clouds may be quite dissimilar.

There is strong evidence for the latter proposition in the conditions that prevail in and near the associations of young, hot, blue-white stars—classified as O and B stars—which are the most spectacular groupings on wide-angle photographs of the Large Cloud taken in blue and ultraviolet light.

Many OB associations also exist in the Milky Way. They are generally found near or inside large interstellar clouds of cosmic dust and molecular hydrogen. We reason that for the nearer parts of our galaxy, conditions inside these cloud complexes are especially favorable for the formation of groupings of hot stars. Inside the dust clouds, temperatures are often as low as 20°K. This implies that the particles and their component molecules and atoms are not in rapid motion. A clump of cosmic dust and molecules having such a low temperature can do little else but collapse under its own gravity to become a protostar embedded in the cold surrounding medium. When the cold, nonluminous protostar is in the first stages of formation, its molecules are protected by the screening action of the cosmic dust from disruption by ultraviolet radiation. But as the protostar continues to collapse, temperatures in its deep interior rise sufficiently to initiate the process of atom-cooking, and a real star emerges.

In the Magellanic Clouds the whole process of the formation of OB associations must be quite different. For one thing, these hot stars are found in regions where very little cosmic dust is present. In the Large Cloud, for example, the Shapley Constellation I, a spectacular grouping of fifty O and B giant and supergiant stars, is situated in a section that is remarkably free of cosmic dust. The absence of a concentration of cosmic dust indicates that there is probably only a small amount of molecular hydrogen present. But when we look more closely, we find that the whole grouping is embedded in a vast complex of atomic hydrogen whose presence is established by radio observations of the 21-centimeter spectral line of neutral atomic hydrogen.

Optical and radioastronomy studies have shown that the youngest stars in Constellation I, the blue-white giant O

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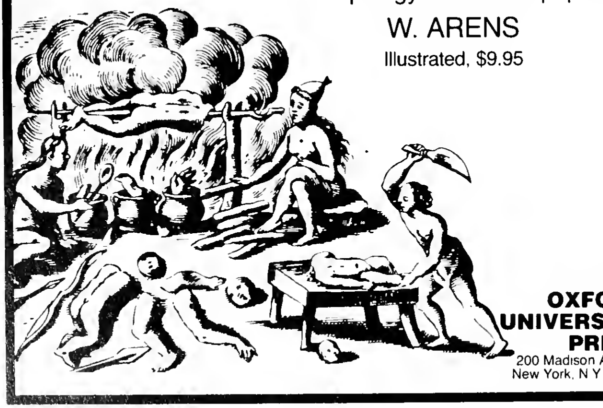

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and B stars, probably have a total mass of 5,000 solar masses. There is as yet little evidence for the presence of intrinsically fainter stars, but there ought to be some of these stars too. The mass of the neutral hydrogen cloud, however, is surprisingly large, about 5,000,000 solar masses, a thousand times the mass of all the OB stars together.

There is some further useful information that should be considered. Each of the fifty O and B stars in Constellation I emits one thousand to ten thousand times as much radiation as our sun pours into space. Astrophysicists versed in the theory of star formation have found that the ages of these stars are about twenty million years or less. Radial velocity measurements show that these stars move with respect to each other at rates of the order of about five miles per second, which means that at most they can have traveled only 600 light-years since they were formed. Since we know the distance to the Large Magellanic Cloud quite precisely, we deduce that these O and B stars can now be seen at positions that are no more than twelve arc minutes away (less than half the apparent diameter of the moon) from the place where they were born. They must therefore have been born within, or very close to, the outer boundaries of the gas clouds associated with Constellation I. By contrast, star birth in the Milky Way is basically associated with the presence of cosmic dust and molecular hydrogen. Since no such dust is present in the required concentration in or near Constellation I, star birth in the Magellanic Clouds must take place according to processes that differ from those observed in the Milky Way.

In addition to the inferred difference in star evolution between our galaxy and the Magellanic Clouds, optical astronomers and X-ray astrophysicists are researching other aspects of these neighbor galaxies. Their value for astrophysical research depends basically on their being the closest external galaxies to the Milky Way, yet neatly separated from it. Their study is still in its infancy, however, because the equipment needed for their proper investigation has only recently become available. But surely they must and will be studied further.

An authority on galactic structure and dynamics, Bart J. Bok is professor emeritus of astronomy at the University of Arizona.

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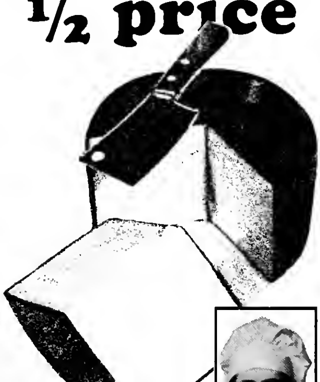

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I had come a long way from Chuckles and Black Cat gum, but the taste of all those exotic dishes was basically the same, a complicated but not at all subtle flavor that occurs in four quite different plants for two different chemical reasons. The unaided palate easily detects taste similarities between licorice, fennel, anise, and star anise. But it took most of human history before it was possible to say what was the cause of the common flavor locked up in such unlikely a set of plant sources as licorice roots, fennel bulbs, anise seeds, and the whorled, woody carpels of the star anise.

Licorice, in fact, stands alone. An herb of the legume family, licorice is botanically unrelated to the other three plants. Pieces of its root were found in Tut's tomb. Decoctions and pasty extracts of licorice contain a glucoside called glycyrrhizin (from the Linnaean genus name, *Glycyrrhiza*, or "sweet root"), which is fifty times as sweet as cane sugar and can be detected even when it has been diluted in 20,000 times its volume of water. (The common name licorice is a corruption of the Latin name *liquiritia*, which is itself a corruption of the Greek *glycyrrhiza*. The French word *réglisse* and the German *Lakritze* are other examples of how the liquid sounds of the original word have been sloshed about on the tongues of speakers of various languages. The correct English pronunciation rhymes with miss. We do have a perfectly good word, lickerish, but it comes from lecherous and can mean either lustful or appetizing.

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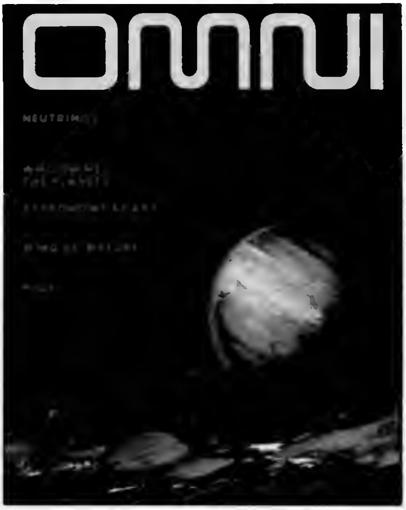

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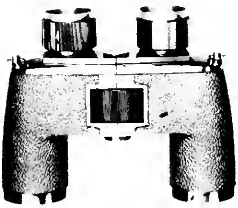

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cause of this family resemblance, the name of their characteristic oil, anethole, is derived from dill, whose Latin name, *anethum*, was confused with anise (the two words in Greek are even closer in appearance).

Out of such nomenclatural chaos, order ought to arise now that organic chemistry has given us the unifying notion of anethole. We should, you would think, be able to go back and look at all the various recipes involving fennel and anise and star anise and come up with a coherent notion of what might be called anethole cuisine. In fact, the only area where there is any notable pattern is beverages. Both fennel and anise have been used in flavoring grain alcohol to produce the aperitifs known variously as ouzo, anisette, pastis, and Pernod. They came into their own after the turn of the century when absinthe was banned because of its toxicity. Absinthe's offending ingredient, oil of wormwood (from *Artemisia absinthium*), evidently tasted something like anethole, so that anise and fennel made convenient surrogates (see recipe).

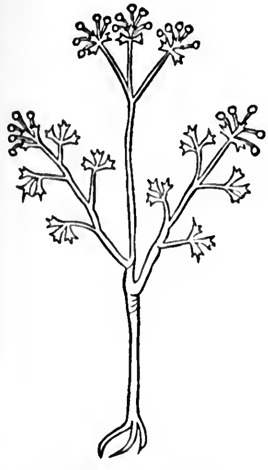
Otherwise, *la cuisine d'anéthol* is a grab bag of culturally determined recipes, without rhyme, but with plenty of individual reasons.

Original geographical distribution of the primeval wild plants has played the most important part in forming the edible legacy we have received from the past. Star anise plays no great role in European cuisines because it did not get to Europe until the end of the sixteenth century, brought there by a British sailor. Its fruit, sometimes called

badian, has since been used as a carminative and as a flavoring element in anisette and in candy making. But in China, the badian is the main source of anise flavor. It gives its distinctive character to chicken, ham, beef, anise-flavored cold cuts, and even nuts (see recipe). Indeed, anise-flavored foods form a major category in northern Chinese meal planning. Because star anise is always the source—and because its anise flavor is stronger than *P. anisum*'s—Chinese anise dishes may exhibit this taste more forcefully than European anise dishes. But it seems more likely that the entirely different role of anise flavor in Europe springs from a widespread historical custom of relegating anise to medicinal decoctions and sweets.

In Britain, aniseeds were most commonly found in the center of tiny sugar candies called comfits. Anise bread and aniseed cookies crop up all over continental Europe. Even anisette is essentially a carminative drink, officially intended to settle the stomach and improve the appetite, like other bitter aperitifs. The drinks themselves are used sometimes in fish sauces, but they are mostly taken by the glass, the last of the elixirs of premodern medicine and a crucial feature of Mediterranean cafe life.

Mediterranean countries are also the home of fennel cookery. In those warm places, the bulb fennel is easily cultivated and prized as a vegetable, dipped raw into condiments (see recipe), in salads, or in a variety of cooked dishes.



Anise (Pimpinella anisum)
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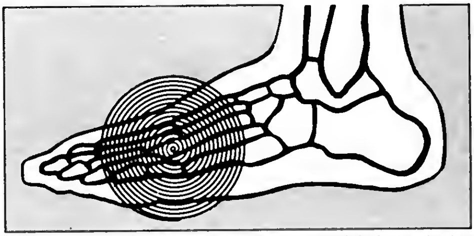
My Feet Were Killing Me...Until I Discovered the Miracle in Germany!



It was the European trip I had always dreamed about. I had the time and money to go where I wanted—see what I wanted. But I soon learned that money and time don't mean much when your feet hurt too much to walk. After a few days of sightseeing my feet were killing me.

Oh, I tried to keep going. In Paris I limped through Notre Dame and along the Champs-Elysées. And I went up in the Eiffel Tower although I can't honestly say I remember the view. My feet were so tired and sore my whole body ached. While everbody else was having a great time, I was in my hotel room. I didn't even feel like sitting in a sidewalk cafe.

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Simple braising occurs nearly everywhere, with the characteristic spices of each region. In the south of France, garlic, in abundance, and olive oil are added to the braising water. Italians often use only olive oil. But they have earned the right to simplicity with bulb fennel, since they have evolved more ways of using it than any other people.

Italians put fennel seeds in salami. In Perugia, they take almost any part of the plant and use it to flavor pork roasts or suckling pig. They fry it in egg and bread crumbs. They bake it with Parmesan cheese. They stuff a roasting chicken with fennel and ham. They flavor dried figs with the seeds. And they purée them for a soufflélike pudding called *sformato*.

Italians are so familiar with fennel that their word for it, *finocchio* (which comes quite straightforwardly from the Latin *foeniculum*, meaning "little hay," and referring to the delicate tops of the plant) has taken on a slang meaning. Because it sounds like *fino occhio*, a "fine" or "delicate eye," *finocchio* has come to mean a male homosexual.

Still, Italians have not completely monopolized creative thinking about the cultivated fennel. Tunisians learned about fennel in their long contact with Italians and improved on *finocchio parmigiana* by stuffing the bulbs with ground meat flavored with tabil, a piquant local spice mixture. Cooks of many cultures have learned to use fennel to flavor fat fishes such as mullet, mackerel, and *loup*. Jews put fennel into a standard white sauce for fish. And, at the cutting edge of culinary invention, the brothers Troisgros of Roanne have refined this idea with their Sauce Albert Prost, essentially a cream sauce with fennel and parsley.

As for licorice, it is rarely, if ever, used in domestic cookery. But in commercial candy making, it continues to hold its own, as it has since time immemorial. Chaucer knew it as a proto-Binaca that people chewed "to smellen swete." In Elizabethan times, it was cultivated in the neighborhood of Pontefract Castle in Yorkshire. Pontefract is still the center of the British licorice industry and Pontefract cakes are a well-known confection. I have never eaten any, but I think I am now mature enough to like them.

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

Licorice (Glycyrrhiza glabra)
The Bettmann Archive

Cuori di Finocchio in Pinzimonio
(Marinated Fennel Hearts)

2 fennels
½ cup olive oil
Salt
Freshly ground black pepper

1. Cut off the tops of the fennel. Remove the outer leaves and discard. Cut the bulbs in quarters, wash carefully, and then dry them.
2. Put the olive oil in a bowl. Season with salt and pepper, abundantly.
3. Dip pieces of fennel in the oil mixture (*pinzimonio*) and eat them. This Roman specialty can also be prepared with hearts of celery.

Yield: Approximately four servings

Szechuan Cashews
(with thanks to Chiang Jung-feng and Ellen Schrecker)

2 cups raw cashews
5 pieces star anise
4 teaspoons Szechuan peppercorns
3 tablespoons soy sauce
1 teaspoon salt
1 teaspoon sesame oil
1 piece of fresh ginger, about 2-inches long, unpeeled, and cut into 4 chunks

(Note: All of the above ingredients are available in Chinese markets.)

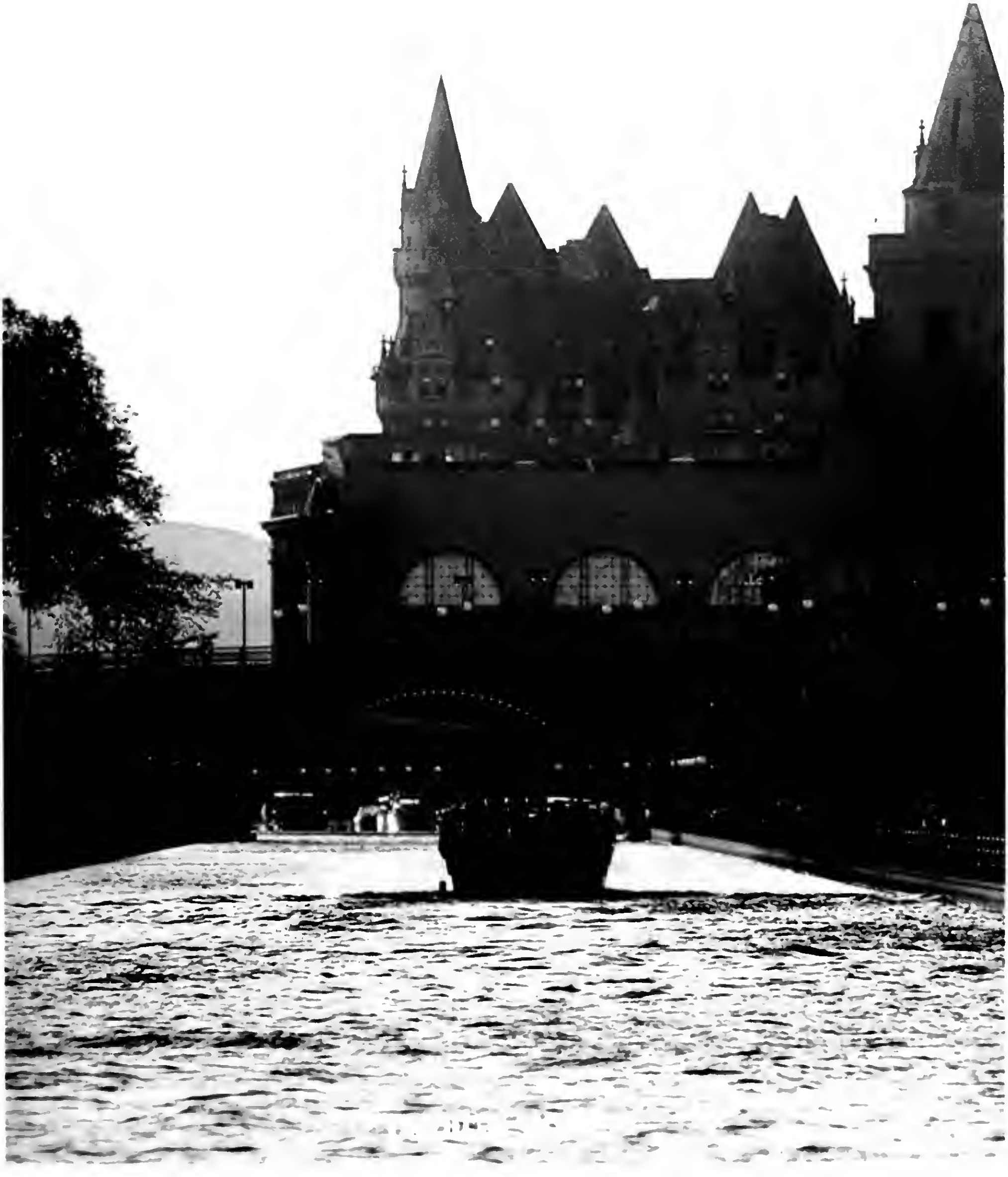
1. Put all the ingredients in a saucepan with 3½ cups water. Bring to a boil, lower heat, and simmer for 1¼ hours or until most of the liquid has been absorbed. Toward the end of the process, stir often.
2. Let cool. Add more salt if necessary. Refrigerate until ready to serve as a snack or with cocktails.

Anisette

1 quart vodka
3 tablespoons aniseed, crushed
1 pinch ground cinnamon
1½ tablespoons ground coriander
2½ cups sugar

1. Into the vodka, pour the aniseed, cinnamon, and coriander. Let infuse in a closed glass container for one month.
2. Melt the sugar in a small amount of water. Mix together with the vodka mixture. Strain through several layers of cheesecloth or through coffee filter paper. Pour into bottles.

Yield: About 7 cups anisette



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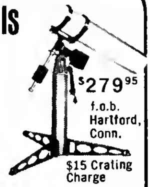

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THE MEDUSA AND THE SNAIL, by Lewis Thomas. *The Viking Press, $8.95; 175 pp.*

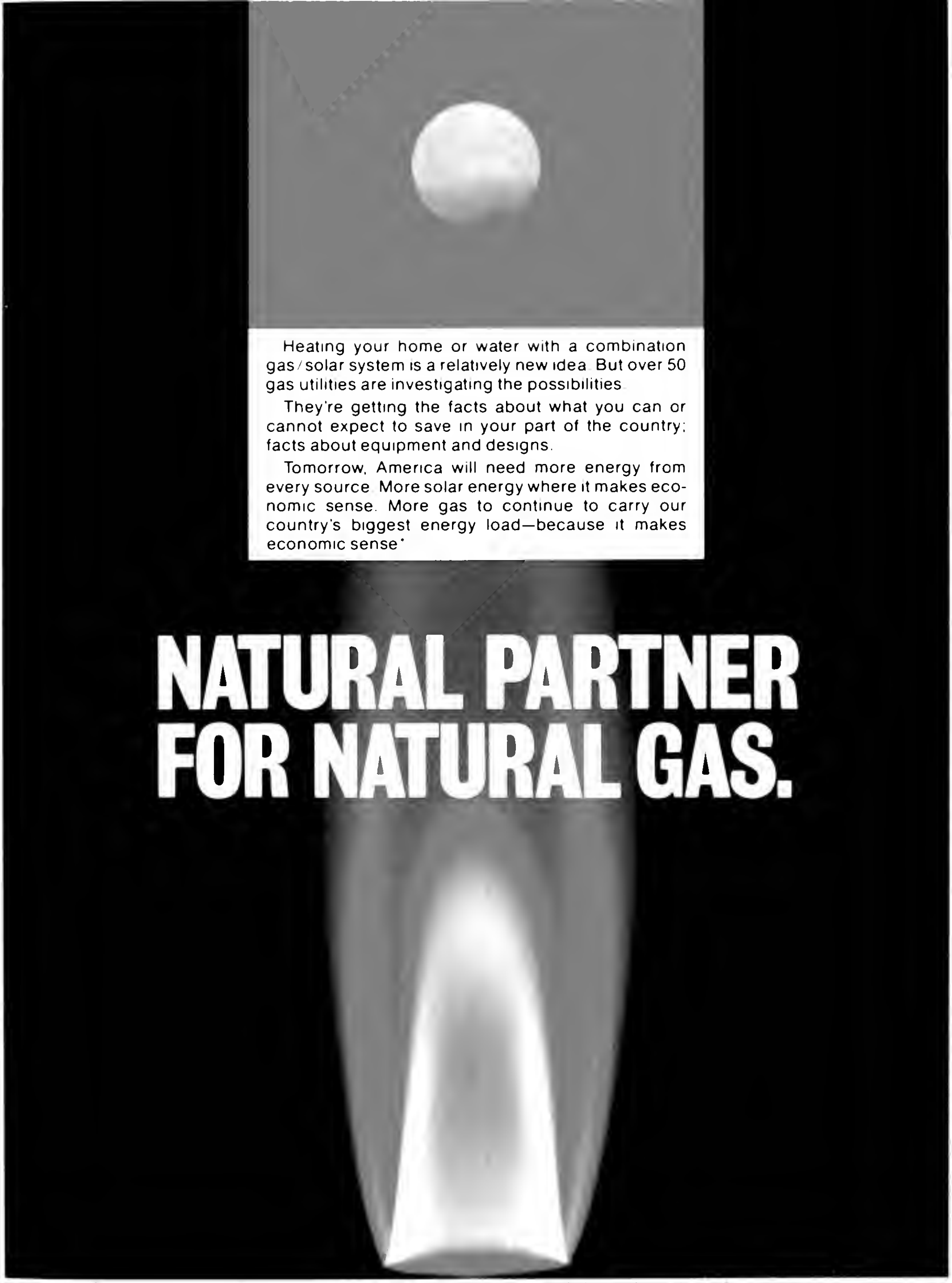
In 1974 the Viking Press published a slim collection of essays titled *The Lives of a Cell.* The author was Lewis Thomas, then sixty-one years old, a prolific and distinguished biomedical scientist who was—and still is—president and chief executive officer of the Memorial Sloan-Kettering Cancer Center in New York. The essays were not altogether easy reading. They had originally appeared in the *New England Journal of Medicine* under the heading "Notes of a Biology Watcher," and Thomas had not felt it necessary to define for his readers such terms as mycetocyte or prokaryotic or to explain how mitochondria convert food into usable energy. The book, Thomas's first, was nevertheless a smash hit. Scientists and nonscientists alike were enthusiastic in their praise, and in 1975 it won a National Book Award after two panels of judges had vied for the privilege of honoring its author. (In the end the arts and letters panel won out over the science panel.) *The Lives of a Cell* has now sold more than 250,000 copies in the United States alone and has been translated into eleven languages.

Thomas's essays were classified by his publishers as biology/philosophy. But, given the nature of his literary gifts, they might as well, or better, have been classified as poetry. One does not need to know much about the evolution of the biosphere, for instance, or even to care much about it, in order to respond with wonder and delight to the passage that brings *The Lives of a Cell* to a close. It comes at the end of an essay, "The World's Biggest Membrane," in which Thomas explains how the atmosphere, the sky, makes life possible on earth, and why "for sheer size and perfection of function, it is far and away the grandest product of collaboration in all of nature." He writes:

> It breathes for us, and it does another thing for our pleasure. Each day, millions of meteorites fall against the outer limits of the membrane and are burned to nothing by the friction. Without this shelter, our surface would long since have become the pounded powder of the moon. Even though our receptors are not sensitive enough to hear it, there is comfort in knowing that the sound is there overhead, like the random noise of rain on the roof at night.

A new collection of essays by Thomas, which display the same perfectly controlled fusion of metaphor and scientific fact that distinguished *The Lives of a Cell,* has now been published under the title *The Medusa and the Snail.* In many of the pieces, most of which were also originally written for the *New England Journal of Medicine,* the author returns to themes that he sounded in his earlier book. Thus again and again he describes and marvels at the intricate ways in which living organisms are linked together and, as in the creation of the sky, collaborate with one another. In the essay from which the book takes its title, for example, Thomas writes of a sea slug living in the Bay of Naples that becomes entrapped within the body of a medusa, or jellyfish. There it nibbles away at its captor until, in time, the jellyfish is reduced to a tiny vestige of itself that lives on as a parasite attached to the skin of the slug. Contemplating this arrangement, Thomas finds himself at a loss for a moral but not for words. "The thought of these creatures gives me an odd feeling," he writes. "They do not remind me of anything, really. I've never heard of such a cycle before. They are bizarre, that's it, unique. And at the same time, like a vaguely remembered dream, they remind me of the whole earth at once. I cannot get my mind to stay still and think it through."

Thomas finds the workings of his



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own unconscious as puzzling as the behavior of the slug and the jellyfish. Noting that warts can be removed by hypnotic suggestion, which means by some unconscious process, he wonders how this can be. "This is not the sort of confused, disordered process you'd expect at the hands of the kind of Unconscious you read about in books, out at the edge of things making up dreams or getting mixed up on words or having hysterics," he writes. "Whatever, or whoever, is responsible for this has the accuracy and precision of a surgeon." This unknown remover of warts, Thomas observes admiringly, "must be a cell biologist of world class, capable of sorting through the various classes of one's lymphocytes, all with quite different functions which I do not understand, in order to mobilize the right ones and exclude the wrong ones for the task of tissue rejection." He adds ruefully, "If it were left to me, and I were somehow empowered to call up lymphocytes and direct them to the vicinity of my wart (assuming that I could learn to do such a thing), mine would come tumbling in all unsorted, B cells and T cells, suppressor cells and killer cells, and no doubt other cells whose names I have not learned, incapable of getting anything useful done."

Although Thomas's new book is subtitled *More Notes of a Biology Watcher*, his attention turns from time to time to matters that do not ordinarily concern biologists as they go about their business. For young people who want to become doctors, he prescribes an undergraduate course of studies consisting mainly of classical Greek, English, history, and the literature of at least two foreign languages. He speculates about the nature of human selfness and about the relationship between thought and music. He explains why he gets so much pleasure out of reading Montaigne. He writes an essay on punctuation, noting that what he likes best in T.S. Eliot's poetry are the semicolons: "You cannot hear them, but they are there, laying out the connections between the images and the ideas. . . . Sometimes you get a glimpse of a semicolon coming, a few lines farther on, and it is like climbing a steep path through the woods and seeing a wooden bench just at a bend in the road ahead, a place where you can expect to sit for a moment, catching your breath."

Thomas is, or so he appears in his essays, a man of sunny temperament. After reading him we feel better about ourselves and the world. Without mawkishness, but with a reassuring graininess and specificity, he celebrates life as it has evolved on earth, and he cannot find it in himself to denigrate a species, man, that has produced the music of Bach. He rejects the existentialist notion that the universe is "an insensate contraption" in which "we have no obligation except to our individual selves and to the genes that invent those selves."

Indeed, in one of the most engaging and joyous essays in his new book, Thomas even takes the unfashionable position that man is innately, that is, genetically, good. He recalls how, on a visit to a zoo in Tucson, he stood between two artificial ponds with clear glass walls. By turning his head one way he could watch a family of beavers at play; by turning it the other way he could watch a family of otters. He writes:

> I was transfixed. As I now recall it, there was only one sensation in my head: pure elation mixed with amazement at such perfection. Swept off my feet, I floated from one side to the other, swiveling my brain, staring astounded at the beavers, then at the otters. I could hear shouts across my corpus callosum, from one hemisphere to the other. I remember thinking, with what was left in charge of my consciousness, that I wanted no part of the science of beavers and otters. . . . All I asked for was the full hairy complexity, then in front of my eyes, of whole, intact beavers and otters in motion.

Unlike the sea slug and the jellyfish, the beavers and the otters taught Thomas something:

> I came away from the zoo with . . . a piece of news about myself; I am coded, somehow, for otters and beavers. I exhibit instinctive behavior in their presence, when they are displayed close at hand behind glass, simultaneously below water and at the surface. I have receptors for this display. Beavers and otters possess a "releaser" for me, in the terminology of ethology, and the releasing was my experience. What was released? Behavior. What behavior? Standing, swiveling flabbergasted, feeling exultation and a rush of friendship.

Thomas goes on to speculate that we are all endowed with genes that determine our reactions to beavers and otters—and perhaps to humans as well. "We are stamped with stereotyped, unalterable patterns of response, ready to be released," he writes. "And the behavior released in us, by such confrontations, is, essentially, a surprised

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affection. . . . Left to ourselves, mechanistic and autonomic, we hanker for friends."

Reflecting further on the emotions that overwhelmed him at the Tucson zoo, Thomas concludes that altruism—"a jargon word for what used to be called love"—may be our most primitive attribute.

> Or perhaps [he adds] it is immediately at hand, waiting to be released, disguised now, in our kind of civilization, as affection or friendship or attachment. I don't see why it should be unreasonable for all human beings to have strands of DNA coiled up in chromosomes, coding out instincts for usefulness and helpfulness. Usefulness may turn out to be the hardest test of fitness for survival, more important than aggression, more effective, in the long run, than grabbiness.

It is an idea as comforting as the thought of all those meteorites falling on the sky with the unheard sound of rain on the roof.

Spencer Klaw teaches at Columbia's Graduate School of Journalism and is at work on a book about John Humphrey Noyes, the nineteenth-century reformer who established the utopian community at Oneida, New York.

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Additional Reading

Whales (p. 46)

Whales, Dolphins, and Porpoises, edited by Kenneth Norris (Berkeley: University of California Press, 1977), is a comprehensive survey of cetology available in most libraries. Edited by William E. Schevill, *The Whale Problem: A Status Report* (Cambridge: Harvard University Press, 1974) includes discussions of the distribution, numbers, and management of whales from all over the world. This book is the result of a conference sponsored by the U.S. Department of the Interior and others. The January 1979 issue of *National Geographic* has two articles illustrated with photographs by Al Giddings: "Humpbacks: The Gentle Whales," by Sylvia A. Earle (pp. 2–17), and "Humpbacks: Their Mysterious Songs," by Roger Payne (pp. 18–25). "Songs of the Humpback Whale," a recording of whale songs, is bound into the issue. *The Year of the Whale*, by Victor B. Scheffer (New York: Charles Scribner's Sons, 1969), a documented natural history of the sperm whale, includes an annotated bibliography of seven whaling classics. Faith McNulty writes of her experiences observing and recording whales in *The Great Whales* (Garden City: Doubleday and Co., 1974). Another general book is *The Whale: Mighty Monarch of the Sea*, written by Jacques-Yves Cousteau and Philippe Diole (Garden City: Doubleday and Co., 1972).

Ground Squirrels (p. 50)

The ecology and physiology of Tioga Pass ground squirrels are described by M. L. Morton in "Seasonal Cycles of Body Weights and Lipids in Belding Ground Squirrels (*Bulletin of the Southern California Academy of Sciences*, vol. 74, no. 3, pp. 128–43) and by M. L. Morton, C. S. Maxwell, and C. E. Wade in "Body Size, Body Composition, and Behavior of Juvenile Belding Ground Squirrels" (*The Great Basin Naturalist*, June 30, 1974, pp. 121–34). Paul W. Sherman discusses the adaptive significance of alarm calling in "Nepotism and the Evolution of Alarm Calls" (*Science*, vol. 197, no. 4310, pp. 1246–53). The behavior of other group-living ground squirrels is the subject of two papers by Christopher Dunford, "Social System of Round-tailed Ground Squirrels" (*Animal Behaviour*, vol. 25, no. 4, pp. 885–906) and "Behavioral Limitations of Round-tailed Ground Squirrel Density" (*Ecology*, vol. 58, no. 6, pp. 1254–68). Two general books are *Adaptation and Natural Selection: A Critique of Some Current Evolutionary Thought*, by George C. Williams (Princeton: Princeton University Press, 1966), and *Behavioural Ecology*, edited by John R. Krebs and Nicholas B. Davies (Sunderland: Sinauer Associates, 1978). *Reproductive and Social Behavior of Belding's Ground Squirrels*, a narrated, 16-mm color film recently produced by Paul W. Sherman and George A. Bartholomew, can be rented or purchased from the University of California Extension Media Center, Berkeley, California 94720.

Rot (p. 60)

Many foods naturally contain small amounts of toxins and, when eaten in sufficient quantity, can have adverse effects on people. This subject is thoroughly covered in *Toxicants Occurring Naturally in Foods*, 2nd. ed. rev., edited by the Food and Nutrition Board (Washington: National Academy of Sciences, 1973). Daniel H. Janzen's original article, "Why Fruits Rot, Seeds Mold, and Meat Spoils," appeared in *The American Naturalist*, vol. 111, no. 980, pp. 691–713. The effects of a bacterial toxin are discussed in "*Clostridium perfringens* Food Poisoning," by M. Nakamura and J. A. Schulze (*Annual Review of Entomology*, vol. 24, 1970, pp. 359–72); fungal effects are described in "Fungus Toxins Affecting Mammals," by P. J. Brook and E. P. White (*Annual Review of Phytopathology*, vol. 4, 1966, pp. 171–94). A more general work is "Implications of Mycotoxins for Human Health," by T. C. Campbell and L. Stoloff (*Journal of Agricultural and Food Chemistry*, vol. 22, 1974, pp. 1006–15). Ways to save foods from spoilage are presented in R. G. Tomkins's "The Microbiological Problems in the Preservation of Fresh Fruit and Vegetables" (*Journal of the Science of Food and Agriculture*, vol. 2, 1951, pp. 381–86). Not all microbial byproducts are disadvantageous; for these see "Biogenesis of Cheese Flavor," by T. Kristoffersen (*Journal of Agricultural and Food Chemistry*, vol. 21, 1973, pp. 573–75) and "Alcohol, Beer, and Wine as Foods," by C. P. Richter (*Quarterly Journal of Studies on Alcohol*, vol. 14, 1953, pp. 525–39).

Bees (p. 66)

Karl von Frisch's *The Dancing Bees: An Account of the Life and Senses of the Honey Bee* (New York: Harcourt Brace and Jovanovich, 1961) is an introduction to the author's work. "Learning and Memory in Bees," by Randolf Menzel and Jochen Erber (*Scientific American*, July 1978, pp. 102–10), discusses the neural basis of programmed flower identification behavior in bees. *The Selfish Gene*, by Richard Dawkins

(New York: Oxford University Press, 1976), is a popularization of a new social theory. Dawkins argues that our behavior has evolved to suit the purposes of the gene and that natural selection works on individual genes rather than on whole species. Bees are an example of an animal whose behavior is mostly of genetic origin. Donald R. Griffin's *The Question of Animal Awareness: Evolutionary Continuity of Mental Experience* (New York: Rockefeller University Press, 1976) addresses the difficulties involved in scientific efforts to understand the nature of animal communication. For a charming book, written at the turn of the century, see *The Life of the Bee*, by Maurice Maeterlinck (New York: Dodd, Mead and Co., 1970).

Doors (p. 76)

In *The Poetics of Space* (Boston: Beacon Press, 1969), Gaston Bachelard discusses the relation between literature and the contained spaces of architecture. Bachelard argues that an understanding of the phenomenology of architecture can be reached through subjective artistic expression. A psychological-sociological analysis of people's concepts of architecture and space can be found in *Psychology of the House*, by Olivier Marc (London: Thames and Hudson, 1977). Amos Rapoport's *House Form and Culture* (Englewood Cliffs: Prentice-Hall, 1969) concerns the relation of architecture to patterns of society.

Katharine D'Agosta

ERRATUM: The credit for the photograph on pages 36–37 of the March 1979 issue should have read Robert Leopold, Bell Laboratories. The photograph was taken off Saint John's, Newfoundland.

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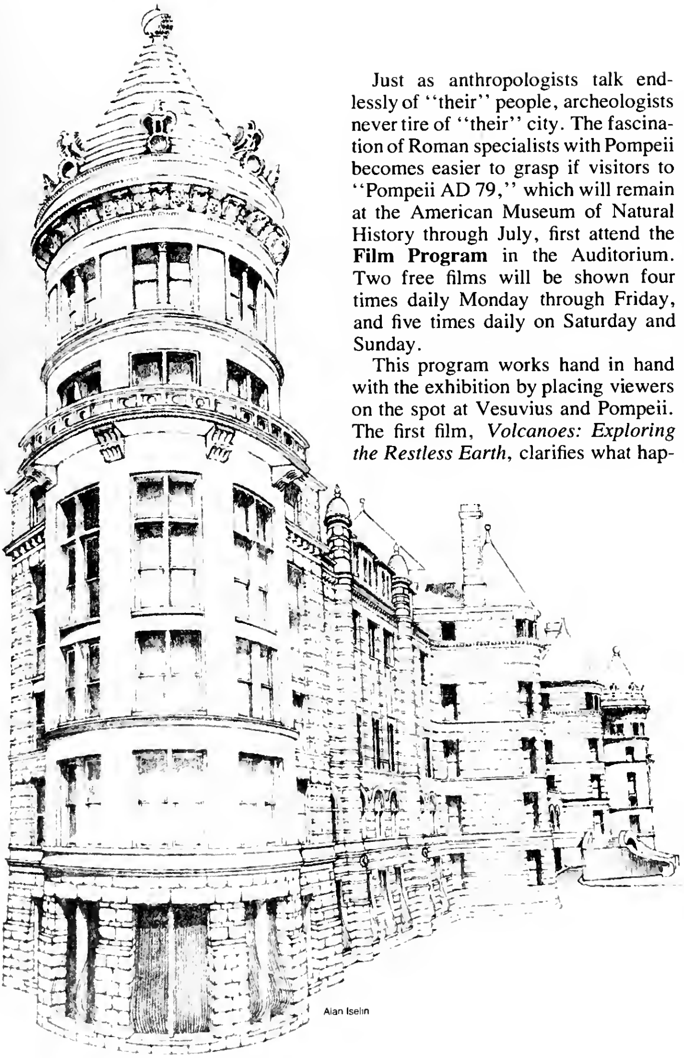
At the Museum



Alan Iselin

Just as anthropologists talk endlessly of "their" people, archeologists never tire of "their" city. The fascination of Roman specialists with Pompeii becomes easier to grasp if visitors to "Pompeii AD 79," which will remain at the American Museum of Natural History through July, first attend the **Film Program** in the Auditorium. Two free films will be shown four times daily Monday through Friday, and five times daily on Saturday and Sunday.

This program works hand in hand with the exhibition by placing viewers on the spot at Vesuvius and Pompeii. The first film, *Volcanoes: Exploring the Restless Earth*, clarifies what happened on August 24, A.D. 79, by providing clear and colorful explanations of continental drift and the formation of volcanoes. Active volcanoes are steam valves for the molten forces inside the earth; all the water found on the earth's surface condensed from steam released from volcanoes. Recent photographs taken by the satellite *Voyager I* have revealed that there is plenty of volcanic activity on Io, a moon of Jupiter. This may mean that Io resembles the earth during its earliest history.

Of the earth's more than five hundred volcanoes, the film shows Surtsey, which has built a new island off the coast of Iceland; Kilauea, an active volcano on the big island of Hawaii; Paricutín in Mexico, which left only the church tower of an Indian village poking above its lava; and another volcano near Iceland that within one week wiped away all traces of civilization on its island. Here, as in Pompeii, houses were buried in ash. This film includes some spectacular photography of orange lava fountains 300 feet high, and of the bluish, partially hardened surface of a lava lake, through which orange veins of molten lava break unceasingly. On Hawaii, slow-moving lava advances on molten toes under a black crust, crawling over the land to the sea. There, as it hardens amid clouds of steam, the lava extends the boundaries of the island.

The program's second film, *The Buried Cities: Pompeii and Hercula-*

neum, gives an impression of the surrounding Campanian countryside, which heaves and bubbles at about seventy sites of varying degrees of volcanic activity. The camera then moves through the empty streets of Pompeii, showing plaster casts of bodies lying where the original impressions were first found. But counteracting this powerful vision of a city of the dead are signs of lively daily activity—a glimpse of the bar at an inn, a baker's oven, presses that extracted oil from olives picked on Vesuvius. Sights such as *have* ("welcome") traced in pavement at the entrance to the House of the Faun bring to life house plans, street maps, and the cork model of Pompeii on display in the Roosevelt Rotunda. The camera shows Vesuvius in the distance as mild mannered and forest covered, then rides a funicular railway to the summit, enabling us to look down the crater's cindery slopes.

The special **Wednesday Evening Programs** accompanying "Pompeii AD 79" will take place at 7:30 P.M. in the Auditorium, through June. Admission for each program is $5 per person, $4 for Participating, Donor, and Elected Members.

On Wednesday June 6, Eugene B. Stavis, director of the American Cinematheque at the Metropolitan Museum of Art, will introduce and comment on a silent version of *The Last Days of Pompeii*, made in 1913. This Italian film closely follows Bulwer-Lytton's

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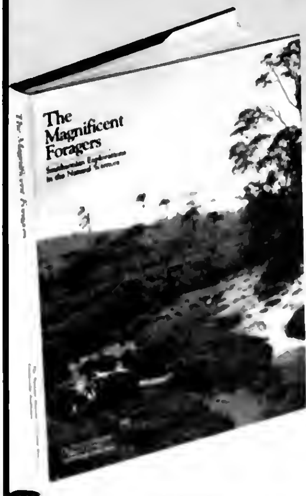

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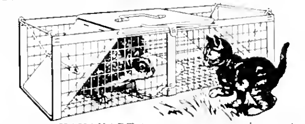

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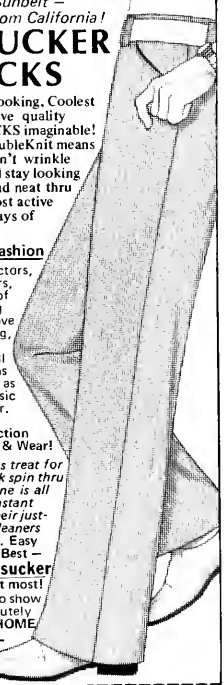

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1834 novel, whose plot and scenery drew heavily on contemporary archeological reports.

On Wednesday June 13, the program, "Volcano!" will consist of three films about volcanoes, the first of which is German filmmaker Werner Herzog's *La Soufrière*. In 1976, La Soufrière, a volcano on the island of Guadeloupe, gave every indication of exploding "with a force equal to five atomic bombs." Herzog, fascinated by the impending disaster, arrived on the evacuated island with a film crew after the last team of scientific observers had left. The filmmakers found and interviewed a couple of hangers-on, who had placed themselves in God's hands and claimed no fear of the coming catastrophe, predicted to resemble the eruption of Mount Pelée, which destroyed the town of Saint Pierre on Martinique, in 1902—an eruption Herzog recalls in stills. In his film, the silent streets of Guadeloupe's main port, hastily emptied of its 75,000 inhabitants, eerily recall Pompeii. The film crew found air conditioners and refrigerators left running, a television still blaring.

The other two films in the "Volcano!" program present artistic studies of hidden forces that shape the earth. *Face of the Earth*, a Canadian film by Bill Mason, posits that "when we look at the face of the earth, we see a mystery." Shots of snow-covered mountains that once lay flat are accompanied by portions of Haydn's *Creation*. *Hot Spot* is Robin Lehman's version of every child's favorite, the Stravinsky sequence from *Fantasia*. Using a sound track composed only of organ music, Lehman has filmed Nyirangongo, an active volcano in Zaire. The beauty of clouds of orange lava and masses of steam lulls viewers, making them temporarily oblivious to the volcano's destructive possibilities.

On June 20, Richard Brilliant, professor of art history and archeology at Columbia University, will present a slide lecture entitled "Pompeii: Rediscovery and Reinvention 1748–1979." Brilliant sees "Pompeii AD 79" as the latest wave of the Western world's interest in the buried city, which has ebbed and flowed continually since Pompeii was rediscovered. Besides beautifully illustrated archeological reports and paintings full of thunderclouds and teetering statuary, Pompeii has inspired several operas and reconstructions of villas in places as far from Italy as Paris, Bavaria, and California. An American epic poem compared Pompeii to Chicago. Goethe, Mme de Staël, Gautier, Malcolm Lowry, and many other novelists felt their inspiration rise in Pompeii. One German novel—in which the archeologist-hero falls in love with a woman's foot after glimpsing it on a Roman bas-relief, looks for traces of the original in Pompeii, and finds a contemporary flesh-and-blood facsimile—greatly impressed Sigmund Freud. He likened the rediscovery and reconstruction of Pompeii to the way a psychoanalyst helps a patient retrieve repressed memories. In his talk, Brilliant will cover this and other artistic and literary ground and will also discuss the future of the 40 percent of the city that remains unexcavated. Buckminster Fuller once suggested that the entire city be covered with a geodesic dome and preserved as a museum *in situ*.

Finally, on Wednesday June 27, Hetty Joyce, curatorial consultant to the American Museum for "Pompeii AD 79," will give a slide lecture entitled "A Place in the Country: Life in a Roman Villa." Like modern city dwellers, Romans liked a little country or sea air away from their Forum's hustle and bustle. To illustrate how wealthy Romans spent their off-hours, Joyce will examine archeological and literary evidence. She will begin with Pliny the Younger's vivid record of the life of a Roman country gentleman and go on to Tacitus's and Suetonius's detailed reports of the emperor Tiberius's scandalous activities at his villa on Capri. Illustrations of Campanian villas and several grander examples will accompany the lecture.

Museum Events

During June and July, the Museum will open at 9:00 A.M. and close at 5:00 P.M. Mondays, Tuesdays, and Thursdays; on Wednesdays and Fridays it will remain open until 9:00 P.M. Hours for "Pompeii AD 79" are different: on Mondays, Tuesdays, and Thursdays, the exhibition will be open noon to 5:00 P.M. until June 15; 11:00 A.M. to 5:00 P.M. after June 15. On Wednesdays and Fridays, exhibition hours are noon to 9:00 P.M. until June 15; 11:00 A.M. to 9:00 P.M. after June 15. The Pompeii Hot Line will operate for the remainder of the exhibition. For ticket information, Museum members and the public may call (212) 999-7777.

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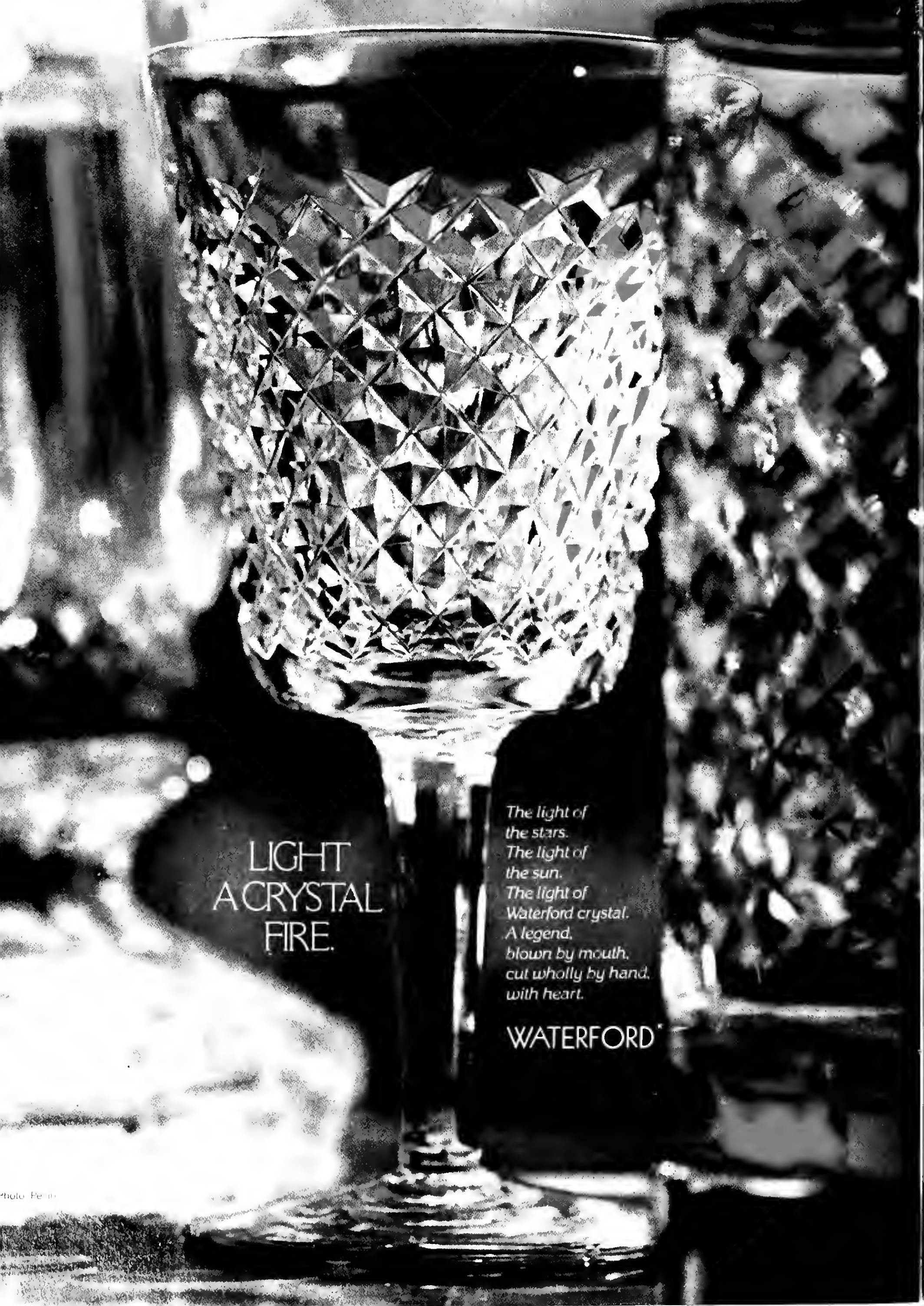
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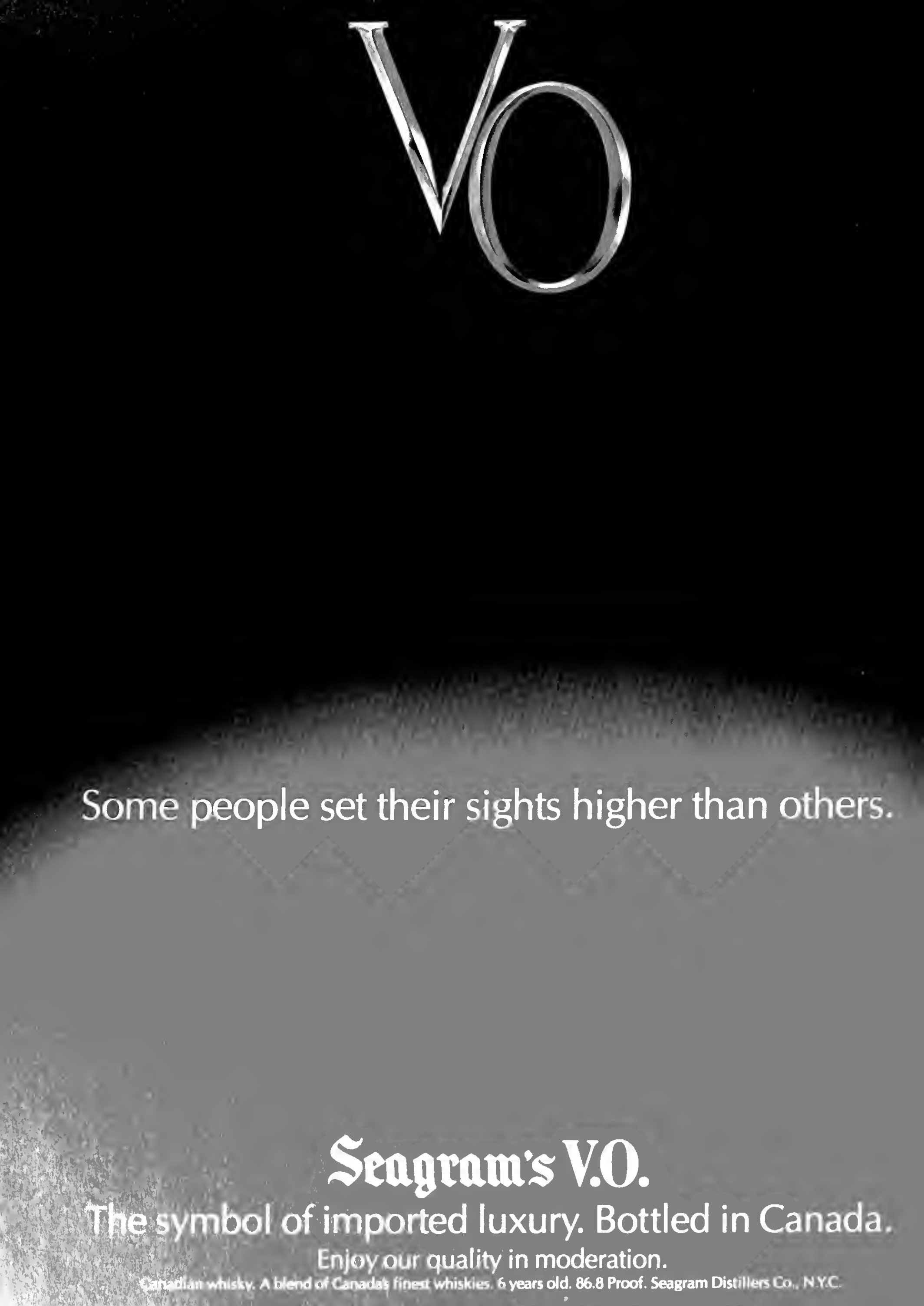
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Authors

For almost half of his life, **Irving Yall** has given his attention to microorganisms, first as a bacteriology student, then as a research associate at Argonne National Laboratory, and for the past twenty years as professor of microbiology at the University of Arizona. During that long span he has logged countless hours in the laboratory investigating the metabolism of microorganisms. It was while doing research on phosphorus metabolism in waste waters that he learned about the hydrocarbon-ingesting capability of the bacterium on which his article in this issue of *Natural History* is based. Yall is a member of the American Association for the Advancement of Science, the American Society for Microbiology, and the American Chemical Society.

Donald R. Hill first saw Carnival—the annual West Indian festival—in the early 1970s during field trips to the islands of Carriacou and Trinidad. In 1973, when he became assistant curator of education at the American Museum of Natural History, he was delighted to discover Carnival was being held in Brooklyn. At about the same time, he began amassing a sizable collection of recorded and taped Caribbean music—mostly calypso, but also salsa and reggae. Hill is also not averse to bluegrass and string quartets. Now assistant professor of anthropology at State University College, Oneonta, New York, Hill has been looking into students' Halloween celebrations, which "have grown more and more elaborate since the late 1960s. Now they're the nearest parallel around here to Carnival."

Before moving to Oneonta in 1978, Hill taught at Hunter College, where he hired as his graduate assistant **Robert Abramson**. A native of New York City's borough of Queens, Abramson, who had previously concentrated on African studies, became increasingly interested in Brooklyn's ethnic diversity. Now a graduate student in anthropology at the University of Pennsylvania, he plans to return to Brooklyn to research his thesis on the West Indian community and Carnival's symbolism.

Pygmy chimpanzees are similar to the common ancestor of humans and African apes, according to **Adrienne L. Zihlman.** This view is consistent with protein biochemical evidence of a recent divergence—evidence used in the article in this issue to show that *Ramapithecus* is odd ape out. Since earning her Ph.D. in 1967, Zihlman has been associate professor of anthropology at the University of California, Santa Cruz, with "no relief in sight." She has written extensively on the evolution of bipedalism and on the role of women in evolution. Gardening and wildlife photography are things she enjoys, and like her coauthor she loves opera and Scrabble.

The split between biochemical and paleontological evidence was what first drew **Jerold M. Lowenstein** to the *Ramapithecus* controversy. As a result of his interest, he has developed a radioimmunoassay with which he hopes to throw some light on the relations of fossil species to each other and to living species. An M.D. (Columbia, 1953), Lowenstein is chairman of nuclear medicine at the Pacific Medical Center and associate clinical professor of medicine at the University of California, San Francisco. His research on the evolution of the thyroid led him to do field studies of radioactive iodine uptake in Galápagos Islands reptiles. Founder of the Oceanic Society, he has "sailed several of the seven seas in small boats."

A Ph.D. candidate in the Department of Zoology at the University of Washington, **Paul W. Ewald** began his work with hummingbirds while still an undergraduate at the University of California, Irvine. He writes that his curiosity about hummingbirds is "perpetually rekindled because they offer one of the finest opportunities for testing current theories of animal behavior. The variables influencing behavior can be accurately quantified and manipulated. Besides, they are fun to watch." Known to his colleagues as "Birdman," Ewald plans to continue studying avian behavior. Another project on the burner involves the interaction between genes and culture, and how this interaction can help in the understanding of cultural beliefs.

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Early Patterns of Perception

A biological perspective on infant learning and development may solve "the slippery issue of innate knowledge"

by Peter Marler

The moment of birth is a time of bewilderment as well as discovery. Deprived of the insulation that the egg or womb is so well designed to provide, a newborn's sensibilities are assaulted by a barrage of messages from the external environment. The task of sorting out the important cues from the meaningless ones cannot be put off for long if the infant is to cope with the world's frightening complexities. By means that are still mysterious, human and other young somehow learn to make sense of what is happening around them. Most astonishing of all is their apparent ability, while besieged by a plethora of distractions, to choose courses of action that enable them to survive without getting lost in an endless number of unproductive or even hazardous blind alleys.

This selective sense is the essence of perception in a living being, implying not only the ability to apprehend changes in the environment but also a capacity to organize and interpret what is happening. Thus, the process of perception involves both the sense organs and the brain. I believe that organisms could not possibly learn to perceive the external world with any reasonable—not to mention remarkable—speed without instructions about how best to do so. Beyond possession of the necessary sensory equipment to take in the world, the brain must also sort out relevant information and abstract key items from a myriad of stimuli that impinge on its receptors. It must organize and classify events according to interpretations that permit the organism to obtain food, avoid danger, and negotiate obstacles, to say nothing of the complexities of socializing with other organisms. Thinking about such issues, the contemporary British philosopher of science Karl Popper opined that "our sense organs should be regarded as auxiliaries to our brain. The brain in turn is programmed to select a fitting and relevant model (or theory or hypothesis) of our environment as we move along, to be interpreted by the mind." The more elaborate the organism and its behavior, the more intricate and pervasive must be its innate instructions for the development of such perceptions.

Popper's viewpoint is shared by many contemporary psychologists and neurobiologists, whether they are concerned with perceptual ontogeny in octopuses, rats, or cats, or the development of language in children. Popper makes no bones about including human behavior in his generalizations. Linguist Noam Chomsky argues compellingly for the existence of a "generative grammar" at the heart of all human languages, implying an innate human ability to master grammatical structure. When we "learn" a language, he says, we exploit a special ability to form and understand all sorts of sentences that we have never heard before. Nevertheless, I find that to most researchers the exact nature and extent of the innate components of perception and language are rarely clear.

There is remarkably little hard evidence of the specific kinds of innate influences that bear on the development of perception. Ironically, although ethologists have long stressed innate genetic contributions to human and animal behavior, some of the most compelling clues come, not from ethology, but from psychologists' studies of the process by which human infants learn to understand speech. Infants seem to share with adults an inclination to process speech by dividing its flow into syllabic "compartments" and paying little attention to variations within the compartments. Recent research suggests that even very young children who have not yet learned to talk can recognize differences in the nature of speech sounds. Infants only one month old seem able to distinguish between pairs of sounds that linguists call voiced and unvoiced consonants. These are articulated from different points in the mouth, the [ga]-[ka] pair from the back, the [ra]-[la] and [da]-[ta] pairs from the back of the teeth, and the plosive [ba]-[pa] pair from the front, using the lips. In all pairs, the consonants are voiced by the larynx, but the voicing is released at a different time, resulting in a difference in sound that infants apparently notice. Cross-cultural studies reinforce the conclusion that responsiveness to some of these voice properties is innate. Infants behave similarly even if the speech patterns they have heard do not include these particular consonants. For example, infants can distinguish the [ra]-[la] sounds that Japanese adults find so difficult. Since there is no distinction between this pair of sounds in the Japanese language, Japanese children prob-

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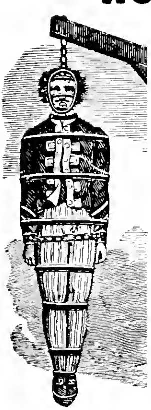

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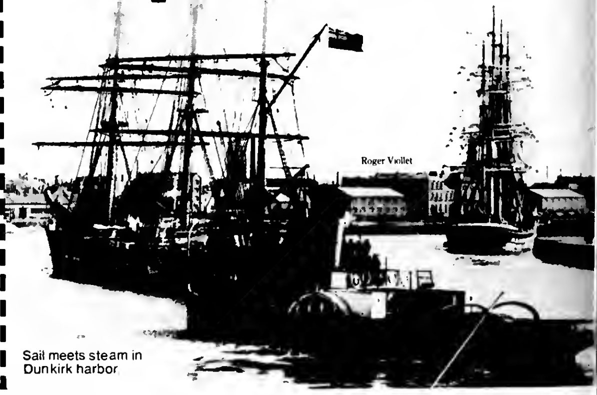

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ably lose the capacity to tell the difference as they grow older, and the natural ability falls into disuse.

Obviously, the subtleties of speech that adults process so rapidly and effortlessly are much more complex than those that infants respond to. By the time we are adults, our perception of speech has been so enriched and transformed by cultural influences that infant predispositions, such as the ability to distinguish certain consonants, may no longer be obvious. However, such predispositions surely play a role in developing adult understanding of speech. If the brain has rules for guiding the development of perception and the genesis of language, how are they formulated and how does the brain use them? Answers to these questions would illustrate how innate knowledge is manifest.

Studies of the way monkeys perceive their own vocal sounds reveal some interesting parallels with the special, innate character of human speech perception. Steven Green of Rockefeller University found that, as in human speech, wild Japanese macaques use systems of sound patterns that convey valuable information to their companions. One such system consists of a variety of coos.

Green noticed that a feature of these sounds that seems to have a special meaning for the macaques is the timing of a frequency inflection, or peak, that may occur at any point in the coo. The macaques seem attuned to messages conveyed by the position of the frequency peak; we have been able to deduce only part of its meaning from the callers' situations. High, smooth peaks that occur early are contact coos—the calls of isolated animals, of individuals in subgroups separated from the main troop, or of young animals separated from regular companions within the group. These callers are usually relatively calm; smooth early highs seem to maintain group cohesion.

Animals producing high peaks late in the coo are more aroused. The vocalizer is actively soliciting contact; estrous females use these calls during early stages of consortship for sexual solicitation. Typically, a subordinate animal gives this call to appease a dominant animal. A careful analysis of the position of peaks in natural usage reveals a distribution of continuously intergrading sound patterns reminiscent of those that show up in studies of human speech. As people talk, they often produce quite imprecise sounds, relying on the listener's ability to "compartmentalize" variations. With an animal, we need similar appreciation of how it hears vocal sounds before we can fully comprehend its communicative interactions.

In order to gain some understanding of monkeys' perceptions of these coo calls, which vary not only in the position of frequency peak but also in other features, a University of Michigan team set out to determine whether the animals could extract one vocal cue while ignoring another. In the laboratory, the group trained Japanese macaques and other monkeys to discriminate between playbacks of field recordings of different classes of coo calls. The animals were required to move a hand in response to sound of one class but not to the other. Differences among species in ability to grasp the distinction between the classes of smooth early and smooth late highs tell us something about perceptual predispositions that an animal uses in learning to respond to biologically important stimuli.

Like human speech, these monkey sounds vary greatly in physical features, such as starting pitch and harmonic structure, from caller to caller and from one rendition to another. This variation seems to slow down the rate at which monkeys learn to classify new calls into the two classes, based on peak position. Nevertheless, Japanese macaques learn quite rapidly. The researchers' next step was to compare the macaques' success with the performance of other species of monkeys presented with the same sounds. One, the vervet monkey, does not use coos. The others, pig-tailed and bonnet macaques, have coo-type calls, but we do not know how or why they use them.

Members of these three species had enormous difficulty distinguishing new calls in the two coo classes—smooth early highs and smooth late highs. The Japanese macaque seems to be predisposed to make the distinction with relative ease, while the other species have more trouble. Nevertheless, by dint of exhaustive training, the other species were eventually coaxed into a level of performance similar to that of the Japanese macaques, showing that the task is not impossible for these monkeys—just harder. Evidently an organism is plastic and can develop ways of coping with an unfamiliar situation, but the right instructions greatly speed and ease learning.

Subsequent experiments compared the ability of Japanese macaques and control species to classify coo calls on the basis of either high position or pitch. Two groups of coos, smooth early and smooth late highs, were carefully counterbalanced for other acoustic variables such as pitch and duration. In this experiment, three Japanese macaques acquired the ability to classify the sounds faster than did members of another species. In the next experiment we used the same coos, sorted this time on the basis of pitch. The animals had to distinguish high- and low-pitched calls and to ignore the position of the frequency peak. Each group of sounds contained both smooth early and smooth late highs, so the position of the peak was not relevant to the solution of this particular task. The result was in complete contrast to the previous experiment. Japanese macaques acquired the ability to discriminate more slowly than the other species. While Japanese macaques are better able to classify groups of coos when they are sorted by peak position, other monkeys can classify better by pitch.

Learning proceeds fastest when the stimuli that enable the animal to discriminate differ consistently along lines that mean something special to the learner. The Japanese macaques' ability to classify coo calls by the position of the peak, more easily than by starting pitch, reflects an inclination to process the coos in a way that parallels their apparent meanings. As yet, we do not know whether the macaques' perceptual mechanisms are innate. All the macaques we have studied grew up in social groups, mostly in the wild, where they must have received and produced many coo sounds. The control species would have had different vocal experience. Whatever the ontogenetic basis, the stimuli clearly do not mean the same thing to adult monkeys of different species. We still have to find out whether monkeys can divide these acoustic continua into categories, as we can speech, and whether we can ask similar questions of infant monkeys. That we are catching glimpses of a process with unusual biological interest—that there *is* something special about perception of calls or speech—is indicated by the revelation that Japanese macaques could distinguish better with the right ear than with the left during the peak relevant task. This right ear dominance echoes the relationship between the human right ear and the left hemisphere of the brain that shows up in response to sounds of speech.

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While the question of the Japanese macaque's innate auditory proclivities is still open, we have new evidence of similar predispositions in songbirds. Even though most bird songs are learned, some birds are innately responsive to the sounds of their own species.

Bird songs are generated by patterns of action that are by far the most complex known from observations of animals' natural behavior. The various meanings of a bird song are presented in parallel, embedded in a single string of sounds, much as a spoken sentence of speech may carry not only a linguistic message but also information about the speaker's personality, emotional state, personal identity, dialect, sex, and so on. Both bird and human must sort out these different kinds of information quickly and accurately without confusing one level with another.

Song sparrows and swamp sparrows are closely related species of the same genus. The swamp sparrow lives in marshy bottomlands of the northeast United States, and the ubiquitous song sparrow is often nearby. Although the male songs of the two species are similar in duration, their structure is very different. The simple song of the swamp sparrow consists of a slow trill of similar slurred, liquid notes. The song sparrow has a much more sprightly, complex song, with alternating trills and phrases that consist of many short, diverse notes. Within each species' different, relatively stable syntactical pattern, the so-called syllables from which the songs are constructed vary greatly in individual acoustic structure, offering tokens of the singer's personal identity.

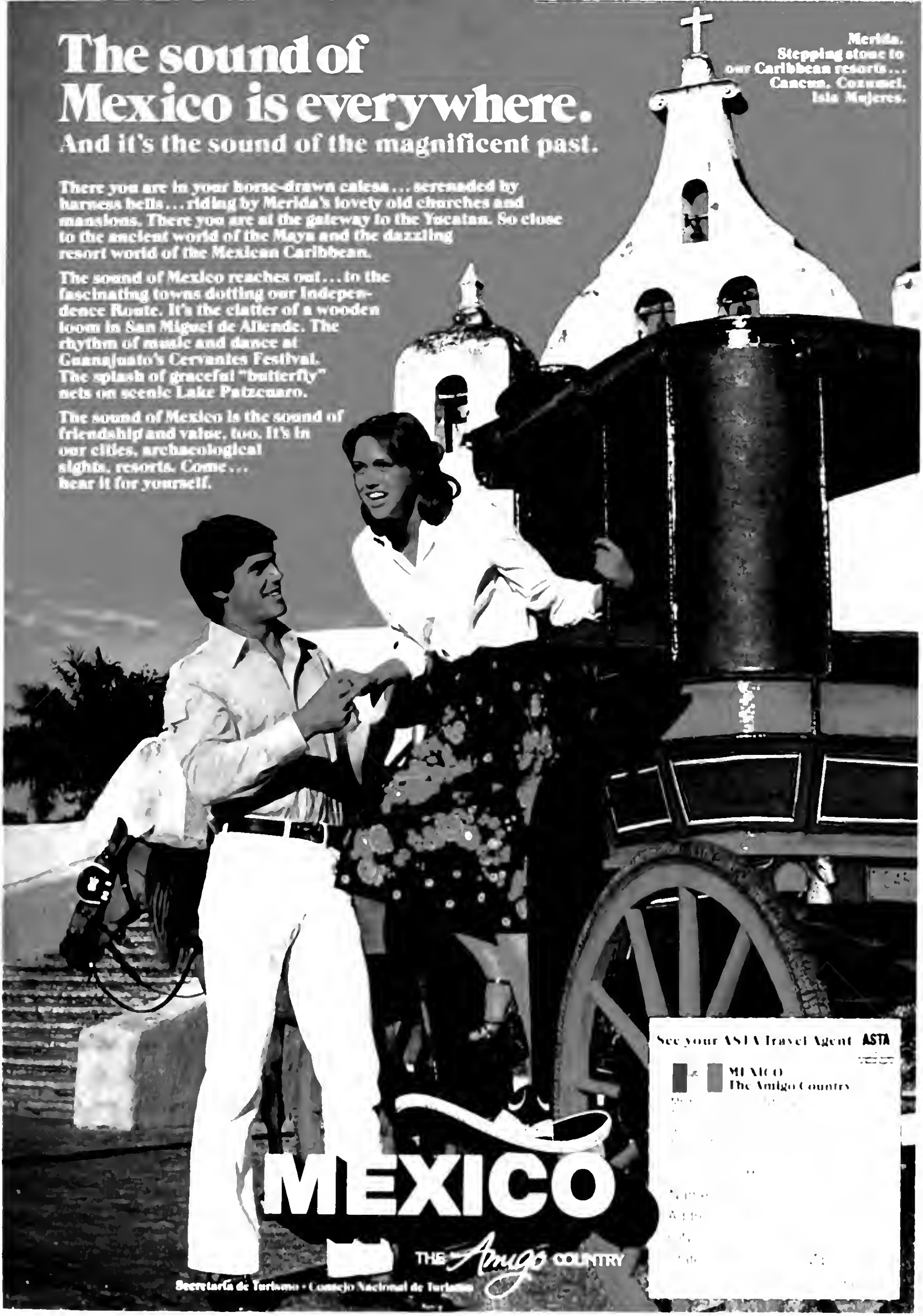
Although the two species prefer different habitats, they are often within earshot of each other. The young of both species need song instruction from adults; the songs of males reared in social isolation are deficient in various ways. The first stage of the bird's song learning is perception of the particular song patterns to be learned. Aside from mimics such as mockingbirds, most birds have songs that remain within species boundaries, staying true to type. This poses something of a paradox, given that most birds have to learn to sing. We wanted to find out whether the learning is selective, whether the birds have innate knowledge of what to imitate.

Our aim was to present young male swamp sparrows with both swamp and song sparrow songs to see if they learned selectively. If they did, we also wanted to distinguish some of the acoustic properties by which the birds decide whether to learn a song. To this end, we created a series of artificial songs by editing out distinctly different "syllables" from tape recordings of the two species' normal local songs, and then splicing them together in a variety of simple, but artificial, syntactical patterns. We hoped to discover the meaning of some of the structural differences between the normal songs of the two species. Our artificial swamp sparrow tapes resembled real song in that they included sequences of identical syllables occurring at various steady rates. On the other hand, our song sparrow tapes mimicked real song by including variable rates of delivery of syllable sequences—some accelerating, some decelerating—and a two-part structure.

We created ten different patterns from song sparrow syllables, and an equivalent set from swamp sparrow syllables. The syllable types were sufficiently distinct that if the birds imitated them, we would be able to tell from which set of patterns they had chosen. The results of our experiments were striking and unexpected.

In the first experiment, we took eight male swamp sparrows from wild nests and reared small groups of them by hand in acoustically shielded chambers. We also reared song sparrows of similar age in the same cages, so that both species were exposed to each other's juvenile calls. When the birds were between twenty and fifty days old—the sensitive period for vocal learning in these species—we trained them for thirty days. Each species heard a set of the twenty synthetic songs arranged in bouts that occur in normal singing, with fifty-two repetitions per day of each song type. Thus, a young bird heard altogether a total of about a thousand songs per day, roughly what it might hear in nature.

Like many other songbirds, our male swamp sparrows learned to sing from memory, coming into full song some months after training. When their ability to sing had crystallized, we discovered that two-thirds of the syllable types they produced were imitations, and that every one was a copy of a swamp sparrow syllable. Thus, the male swamp sparrow learns to sing in an extremely selective manner, imitating the syllables of its own species and rejecting song sparrow syllables. It made no difference at this age whether



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the syllables were presented in swamp-sparrow-like or song-sparrow-like patterns.

The birds seem to choose from the components or syllables out of which the song is constructed and not from its overall pattern. Whereas our birds extracted four of the syllables they learned from one-part songs, which is the normal swamp sparrow pattern, they also extracted eight from two-part models, closer to the typical song sparrow pattern. Five of the songs the birds accepted were in series with a steady rate, normal for swamp sparrows, but seven came from a series with a variable rate, more typical of song sparrow patterns. Although swamp sparrows rejected the song syllables of song sparrows as a basis for learning to sing, they seem to be oblivious at this age to species differences in the temporal patterning of the song.

This experiment still leaves in question the degree to which the birds' selection of particular stimuli to imitate is innate. Their few days of life in nests in the wild might have given the birds enough time to learn to sing. To test this possibility, we removed wild swamp sparrow eggs from nests early in incubation. The eggs were hatched under canaries, and the nestlings reared in the laboratory. We then trained these birds for between twenty and fifty days with synthetic songs, like those used in the previous experiment. Once again, all the young birds chose to imitate only swamp sparrow syllables, showing that an innate predisposition is at work.

Hence, some young songbirds respond to song features peculiar to their species before they themselves begin to sing, just as young of our own species respond to particular aspects of speech sounds before they themselves begin to speak. In both cases, the young initially respond to relatively simple, elementary properties. Full appreciation of more complex aspects of adult sounds comes only as the young mature.

Such predispositions constitute valuable biological constraints on the perceptual learning process. They focus the young organism's attention on an appropriate set of complex sounds and on particular properties that they exhibit. The birds' predispositions guide them to a set of models particular to their species and focus attention on properties that reduce the potential hazard of learning the wrong song. At the same time, the young sacrifice none of their ability to learn more complex features of natural song. Human infants benefit not only from innate encouragement to attend closely to sounds of speech but also from guidance by their natural predispositions in embarking on its perceptual analysis. Speech sounds are enormously complex, and there is still controversy about which ones are, in fact, the best conveyors of meaning.

At this point, we have established that animals possess innate perceptual knowledge. Now we must find out what it is like and how it helps impose order on the process of perceptual development, without constraining free choice so much that the benefits of learning are limited. I am increasingly convinced that in song and swamp sparrows the development of vocal perception proceeds in stages; at each step, different items of innate information blend with different kinds of learned information. A similar innate hierarchical program may enable a human infant to proceed quickly and surely through the complicated process of learning to understand and respond to speech. The existence of such stages of development would increase the likelihood that all human infants tackle the problem in roughly the same way, thus reducing the possibility of private solutions to perceptual problems—solutions that could only hinder efficient use of speaking and speech perception for purposes of social communication, which is, after all, what speech behavior is all about.

I see great promise in using both ethological and psychological approaches to problems of perceptual development. Such a union will go far toward establishing a proper biological viewpoint on the slippery issue of innate knowledge. A young organism's innate responsiveness to certain stimuli by no means commits it to the life of a behavioral automaton. On the contrary, in infant animals, including humans, innate responsiveness may become heavily overlain and transformed by learning during the passage to adulthood. Yet, in subtle ways, it must guide the young organism along certain developmental paths particular to its species without necessarily sacrificing the many advantages of behavioral plasticity.

Peter Marler is professor of animal behavior at Rockefeller University, and director of the university's Field Research Center, Millbrook, New York

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A Quahog Is a Quahog

Whether in New England or New Guinea, folk taxonomies accurately describe nature

Thomas Henry Huxley once defined science as "organized common sense." Other contemporaries, including the great geologist Charles Lyell, urged an opposing view—science, they said, must probe behind appearance, often to combat the "obvious" interpretation of phenomena.

I cannot offer any general rules for the resolution of conflicts between common sense and the dictates of a favored theory. Each camp has won its battles and received its lumps. But I do want to tell a story of common sense triumphant—an interesting story because the theory that seemed to oppose ordinary observation is also correct, for it is the theory of evolution itself. The error that brought evolution into conflict with common sense lies in a false implication commonly drawn from evolutionary theory, not with the theory itself.

Common sense dictates that the world of familiar, macroscopic organisms presents itself to us in "packages" called species. All bird watchers and butterfly netters know that they can divide the specimens of any local area into discrete units blessed with those Latin binomials that befuddle the uninitiated. Occasionally, to be sure, a package may become unraveled and even seem to coalesce with another. But such cases are noted for their rarity. The birds of Massachusetts and the bugs in my backyard are unambiguous members of species recognized in the same way by all experienced observers.

This notion of species as "natural kinds" fit splendidly with creationist tenets of a pre-Darwinian age. Louis Agassiz even argued that species are God's individual thoughts, made incarnate so that we might perceive both His majesty and His message. Species, Agassiz wrote, are "instituted by the Divine Intelligence as the categories of his mode of thinking."

But how could a division of the organic world into discrete entities be justified by an evolutionary theory that proclaimed ceaseless change as the fundamental fact of nature? Both Darwin and Lamarck struggled with this question and did not resolve it to their satisfaction. Both denied to the species any status as a natural kind.

Darwin lamented: "We shall have to treat species as . . . merely artificial combinations made for convenience. This may not be a cheering prospect; but we shall at least be freed from the vain search for the undiscovered and undiscoverable essence of the term species." Lamarck complained: "In vain do naturalists consume their time in describing new species, in seizing upon every nuance and slight peculiarity to enlarge the immense list of described species."

Yet—and this is the irony—both Darwin and Lamarck were respected systematists who named hundreds of species. Darwin wrote a four-volume taxonomic treatise on barnacles, while Lamarck produced more than three times as many volumes on fossil invertebrates. Faced with the practicum of their daily work, both recognized entities where theory denied their reality.

There is a traditional escape from this dilemma: one can argue that our world of ceaseless flux alters so slowly that configurations of the moment may be treated as static. The coherence of modern species disappears through time as they transform slowly into their descendants. One can only remember Job's lament about "man that is born of a woman"—"He cometh forth like a flower . . . he fleeth also as a shadow, and continueth not." But Lamarck and Darwin could not even enjoy this resolution, for they both worked extensively with fossils and were as successful in dividing evolving sequences into species as they were in parsing the modern world.

Other biologists have even forsworn this traditional escape and denied the reality of species in any context. J.B.S. Haldane, perhaps the most brilliant evolutionist of this century, wrote: "The concept of a species is a concession to our linguistic habits and neurological mechanisms." A paleontological colleague proclaimed in 1949 that "a species . . . is a fiction, a mental construct without objective existence."

Yet common sense continues to proclaim that, with few exceptions, species can be clearly identified in local areas of our modern world. Most biologists, although they may deny the reality of species through geologic time, do affirm their status for the modern moment. As Ernst Mayr, our leading student of species and speciation, writes: "Species are the product of evolution and not of the human mind." Mayr argues that species are "real" units in nature both as a result of their history and the current interaction among their members.

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lations inhabiting a definite geographical area, generally at the periphery of a parental species' range. They establish their uniqueness by evolving a genetic program sufficiently distinct that members of the species breed with each other, but not with members of other species. Their members share a common ecological niche and continue to interact through interbreeding.

Higher units of the Linnaean hierarchy cannot be objectively defined, for they are collections of species and have no separate existence in nature—they neither interbreed nor necessarily interact at all. These higher units—genera, families, orders, and so on—are not arbitrary. They must not be inconsistent with evolutionary genealogy (you cannot put people and dolphins in one order and chimps in another). But ranking is, in part, a matter of custom with no "correct" solution. Chimps are our closest relatives by genealogy, but do we belong in the same genus or in different genera within the same family? Species are nature's only objective taxonomic units.

Shall we then follow Mayr or Haldane? I am a partisan of Mayr's view and I wish to defend it with an offbeat but, to my mind, persuasive line of evidence. The repeated experiment is a cornerstone of scientific methods—although evolutionists, dealing with nature's uniqueness through history, do not often have an opportunity to practice it. But in this case, we have a way to obtain valuable information about whether species are mental abstractions embedded in cultural practice or packages in nature. We can study how different peoples, in complete independence, divide the organisms of their local areas into units. We can contrast Western classifications into Linnaean species with the "folk taxonomies" of non-Western peoples.

The literature on non-Western taxonomies is not extensive, but it is persuasive. We usually find a remarkable correspondence between Linnaean species and non-Western plant and animal names. In short, the same packages are recognized by independent cultures. I do not argue that folk taxonomies invariably include the entire Linnaean catalog. People usually do not classify exhaustively unless organisms are important or conspicuous. The Fore of New Guinea have a single word for all butterflies, although species are as distinct as the birds they do classify in Linnaean detail. Similarly, most of the bugs in my backyard have no common name in our folk taxonomy, but all the birds in Massachusetts do. The Linnaean correspondences only arise when folk taxonomies attempt an exhaustive division.

Several biologists have noted these remarkable correspondences in the course of their fieldwork. Ernst Mayr himself describes his experience in New Guinea: "Forty years ago, I lived all alone with a tribe of Papuans in the mountains of New Guinea. These superb woodsmen had 136 names for the 137 species of birds I distinguished (confusing only two nondescript species of warblers). That . . . Stone Age man recognizes the same entitites of nature as Western university-trained scientists refutes rather decisively the claim that species are nothing but a product of the human imagination." In 1966, Jared Diamond published a more extensive study on the Fore people of New Guinea. They have names for all the Linnaean bird species in their area. Moreover, when Diamond brought seven Fore men into a new area populated by birds they had never seen, and asked them to give the closest Fore equivalent for each new bird, they placed 91 of 103 species into the Fore group closest to the new species in our Western Linnaean classification. Diamond relates an interesting tale:

> One of my Fore assistants collected a huge, black, short-winged, ground-dwelling bird, which neither he nor I had seen before. While I was puzzled by its affinities, the Fore man promptly proclaimed it to be a *peteobeye*, the name for a graceful little brown cuckoo which frequents trees in Fore gardens. The new bird eventually proved to be Menbek's coucal, an aberrant member of the cuckoo family, to which some features of body form and leg and bill shape betray its affinity.

These informal studies by biologists have been supplemented in recent years with two exhaustive treatments by anthropologists who are also competent natural historians—Ralph Bulmer's work on vertebrate taxonomies of the Kalam people of New Guinea, and Brent Berlin's study (with botanists Dennis Breedlove and Peter Raven) of plant classification by the Tzeltal Indians of highland Chiapas, Mexico. (I thank Ernst Mayr for introducing me to Bulmer's work and for urging this line of argument for many years.)

The Kalam people, for example, use frogs extensively as food and have divided them into names corresponding with Western species. Most of their

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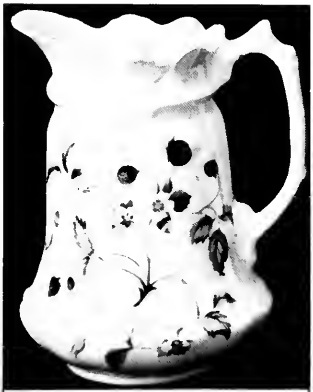

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names have a one-to-one relationship with Linnaean species. In some cases they apply the same name to more than one species, but still recognize the difference: Kalam informants could readily say that there were at least two different kinds of *gunm*, distinguished both by appearance and habitat, even though they had no standard names for them. Sometimes, the Kalam do better than we. They recognize, as *kasoj* and *wyt*, two species that had been lumped incorrectly under the single Western name *Hyla becki*.

Bulmer has recently teamed up with Ian Saem Majnep, a Kalam, to produce a remarkable book (*Birds of My Kalam Country*, Oxford University Press, 1977). More than 70 percent of Saem's names have one-to-one correspondence with Western species. In most other cases, he either lumps two or more Linnaean species under the same Kalam name but recognizes the Western distinction, or else he makes divisions within a Western species but recognizes the unity (in some birds of paradise, for example, he names the sexes separately because only males carry the prized plumage). In only one case does Saem follow a practice that is inconsistent with Linnaean nomenclature—he includes the drab females of two birds of paradise under the same name but uses a different name for the showy males of each species. In fact, Bulmer could only find four cases (2 percent) of inconsistency in the entire catalog of 174 vertebrate species, spanning mammals, birds, reptiles, frogs, and fishes.

Berlin, Breedlove, and Raven published their first study in 1966 explicitly to challenge Diamond's claim for the generality of extensive one-to-one correspondence between folk names and Linnaean species. They held initially that only 34 percent of Tzeltal plant names matched Linnaean species and that a large variety of "misclassifications" reflected cultural uses and practices. But a few years later, in a frank article, they reversed their opinion and affirmed the uncannily close correspondence of folk and Linnaean names. They had, in the earlier study, not fully understood the Tzeltal system of hierarchical naming and had mixed names from several levels in establishing the basic folk groups. In addition, Berlin admitted he had been led astray by a standard anthropological bias for cultural relativism. I cite his recantation, not to show him up, but as a token of my admiration for an act all too rarely performed by scientists (although any scientist worth his salt has changed his mind about fundamental issues):

> Many anthropologists, whose traditional bias is to see the total relativity of man's variant classifications of reality, have generally been hesitant to accept such findings. . . . My colleagues and I, in an earlier paper, have presented arguments in favor of the "relativist" view. Since the publication of that report more data have been made available, and it now appears that this position must be seriously reconsidered. There is at present a growing body of evidence that suggests that the fundamental taxa recognized in folk systematics correspond fairly closely with scientifically known species.

Berlin, Breedlove, and Raven have now published an exhaustive book on Tzeltal taxonomy (*Principles of Tzeltal Plant Classification*, Academic Press, 1974). Their complete catalog contains 471 Tzeltal names. Of these, 281, or 61 percent, stand in one-to-one correspondence with Linnaean names. All but 17 of the rest are, in the authors' terms, "underdifferentiated"—that is, the Tzeltal names refer to more than one Linnaean species. But, in more than two-thirds of these cases, the Tzeltal use a subsidiary system of naming to make distinctions within the primary groups, and all these subsidiaries correspond with Linnaean species. Only 17 names, or 3.6 percent, are "overdifferentiated" by referring to part of a Linnaean species. Seven Linnaean species have two Tzeltal names, and only one has three—the bottle gourd *Lagenaria siceraria*. The Tzeltal distinguish bottle gourd plants by the utility of their fruits—one name for large, round fruits used as containers for tortillas; another for long-necked gourds well suited for carrying liquids; and a third for small, oval fruits that are not used at all.

A second, equally interesting generality emerges from studies of folk classification. Biologists argue that only species are real units in nature, and that names at higher levels of classification represent human decisions about how these packages should be grouped (under the constraint, of course, that such grouping be consistent with evolutionary genealogy). Thus, for names applied to groups of species, we should not expect one-to-one correspondence with Linnaean designations but should anticipate a variety of schemes matched with local uses and culture. Such variety has been a consistent find-

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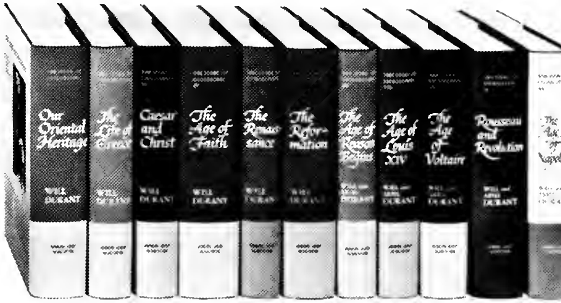

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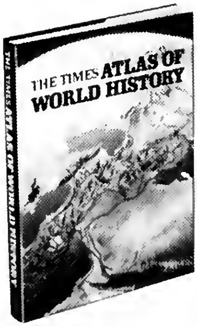

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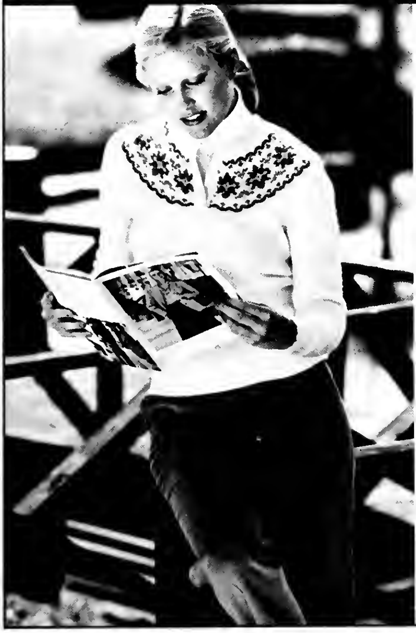

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ing in studies of folk taxonomy. Groups of species are often designated by basic forms attained independently by several evolutionary lines. The Tzeltal, for example, have four broader names for groups of species, roughly corresponding to trees, vines, grasses, and broad-leafed herbaceous plants. These names apply to about 75 percent of their plant species, while others, like corn, bamboo, and agave, are "unaffiliated."

Often, the grouping of species reflects more subtle and pervasive aspects of culture. The Kalam of New Guinea, for example, divide their nonreptilian four-footed vertebrates into three classes: *kopyak*, or rats; *kmn* for an evolutionarily heterogeneous collection of larger game mammals, mostly marsupials and rodents; and *as* for an even more heterogeneous collection of frogs and small rodents. (Under repeated questioning by Bulmer, the Kalam deny any subdivision between frogs and rodents within *as*, although they do acknowledge [and dismiss as unimportant] the morphological similarity between small furry *as* and rodents among *kmn*. They also recognize that some *kmn* have pouches and others do not.) The divisions reflect fundamental facts of Kalam culture. *Kopyak*, associated with excrement and unclean food around homesteads, are not eaten at all. *As* are collected primarily by women and children and, although eaten by most men and collected by some, are forbidden foods for boys during their rites of passage and for adult men who practice sorcery. *Kmn* are hunted primarily by men.

Likewise, birds and bats are all *yakt*, with the single exception of the large, flightless cassowary called *kobty*. The distinction is made for deeper and more complex reasons than mere appearance—for the Kalam do recognize avian characters in *kobty*. Cassowaries, Bulmer argues, are the prime game of the forest and the Kalam maintain an elaborate cultural antithesis between cultivation (represented by taro and pigs) and the forest (represented by pandanus nuts and cassowaries). Cassowaries are also the mythological sisters of men.

We maintain similar practices in our own folk taxonomy. Edible mollusks are "shellfish," but Linnaean species all have common names. I well remember the reprimand I received from a New England shipmate when I applied the informal scientific term "clam" to all bivalved mollusks (to

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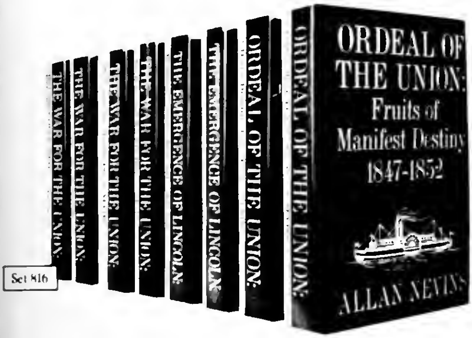

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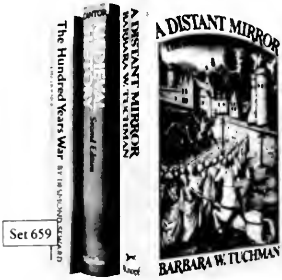

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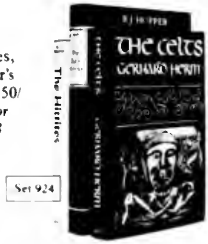

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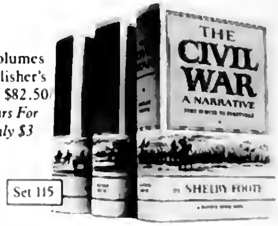

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him a clam is only the steamer, *Mya arenaria*): "A quahog is a quahog, a clam is a clam, and a scallop is a scallop."

The evidence of folk taxonomy is persuasive for the modern world. Unless the tendency to divide organisms into Linnaean species reflects a neurological style wired into all of us (an interesting proposition, but one that I doubt), the world of nature is, in some fundamental sense, really divided into reasonably discrete packages of creatures as a result of evolution. (I do not, of course, deny that our propensity for classifying in the first place reflects something about our brains, their inherited capacities, and the limited ways in which complexity may be ordered and made sensible. I merely doubt that such a definite mode as classification into Linnaean species could reflect the constraints of our mind alone, and not of nature.)

But are these Linnaean species, recognized by independent cultures, merely temporary configurations of the moment, mere way stations on evolutionary lineages in continual flux. I have argued in several columns (August–September 1975, May and June–July 1977) that, contrary to popular belief, evolution does not work this way, and that species have a "reality" through time to match their distinctness at a moment. An average species of fossil invertebrates lives five to ten million years (terrestrial vertebrates have shorter average durations). During this time, they rarely change in any fundamental way. They become extinct, without issue, looking much as they did when they first appeared.

New species usually arise, not by the slow and steady transformation of entire ancestral populations, but by the splitting off of small populations from an unaltered ancestral stock. The frequency and speed of such speciation is among the hottest topics in evolutionary theory today, but I think that most of my colleagues would advocate ranges of hundreds or thousands of years for the origin of most species by splitting. This may seem like a long time in the framework of our lives, but it is a geologic instant, usually represented in the fossil record by a single bedding plane, not a long stratigraphic sequence. If species arise in hundreds or thousands of years and then persist, largely unchanged, for several million, the period of their origin is but a tiny fraction of one percent of their total duration. Therefore, they may be treated as discrete entities even through time. Evolution, at higher levels, is fundamentally a story of the differential success of species, not the slow transformation of lineages.

Of course, if we happen to encounter a species during the geologic microsecond of its origin, we will not be able to make clear distinctions. But our chances of finding a species in this state are small indeed. Species are stable entities with very brief periods of fuzziness at their origin (although not at their demise because most species disappear cleanly without changing into anything else). As Edmund Burke said in another context: "Though no man can draw a stroke between the confines of day and night, yet light and darkness are upon the whole tolerably distinguishable."

Evolution is a theory of organic change, but it does not imply, as many people assume, that ceaseless flux is the irreducible state of nature and that structure is but a temporary incarnation of the moment. Change is more often a rapid transition between stable states than a continuous transformation at slow and steady rates. We live in a world of structure and legitimate distinction. Species are the units of nature's morphology.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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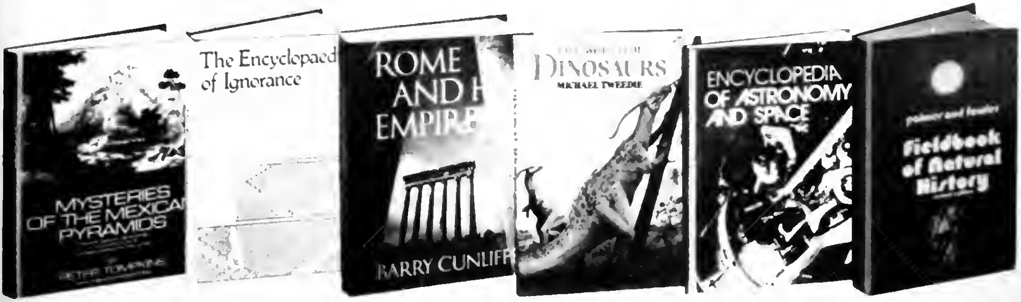

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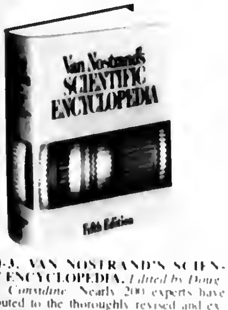

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Our Pound of Flesh

Human populations that are conditioned to prefer animal sources of protein are better prepared for the inevitable and unexpected stresses of life

With the price of meat, fish, cheese, and milk setting records at the supermarket, there is reason to question our penchant for consuming robust quantities of protein derived from animals. In the short run, these rising prices can be met by shifting from choice cuts to hamburgers, hot dogs, and poultry. Increasingly, however, Americans and other affluent peoples may have to fall back upon vegetable sources of protein such as peas and beans, relied upon throughout much of the world. Is this trend something to be alarmed about? Does it represent a lowering of nutritional standards or is it merely an overdue correction of an arbitrary preference—a change for the better, as vegetarian enthusiasts would claim?

Anthropologists are of different minds concerning the significance of the human quest for animal protein and the development of enforced vegetarian diets as a result of population growth and the scarcity of wild or domesticated animals. Some see the demand for animal protein as a factor that has shaped the course of cultural evolution. Others insist that plant protein has seldom been in critically short supply; that a switch from animal to vegetable sources of protein does not threaten human health and well-being but merely requires people to change their tastes.

Several anthropologists have recently advanced theories explaining important cultural phenomena as adaptive responses to the quest for animal protein. Daniel Gross of the City University of New York has tried to show that there is a scarcity of harvestable wild game and fish in the Amazon Basin, and that the Amazon's low human population density—less than one person per square mile—is an adaptation to the level of fish and game production that can be sustained without degrading the forest's faunal resources. I have proposed that the intense warfare characteristic of many aboriginal Amazonian village peoples was required to slow down population growth, disperse settlements in relation to faunal resources, and create no man's lands that could function as game preserves. And Michael Harner has stirred up an international controversy by maintaining that the Aztecs practiced human sacrifice on a large scale because domesticated herbivores were absent in pre-Columbian Mexico. According to Harner, the Aztecs sought to overcome the depletion of faunal resources by consuming the flesh of enemy soldiers ostensibly sacrificed to appease the gods. All these theories have been the subject of debate.

Gross's view has been challenged by Stephen Beckerman of the University of California at Berkeley, who claims that the combined plant and animal protein potential of the Amazonian habitat far exceeds any possible demands of the sparse American Indian populations. He is critical of Gross for failing to include invertebrate animal sources in his estimates of protein productivity. Ants, grubs, caterpillars, and snails are all eaten with gusto by contemporary Indian groups who dwell in Amazonia. Even without sources of animal protein, argues Beckerman, larger populations could have been supported by the numerous protein-rich plants belonging to both domesticated and wild species. Indigenous tropical forest peoples cultivated peanuts and three different kinds of beans—crops whose dry-weight protein content is about the same as that of powdered cow's milk (28 percent). In addition, they could collect Brazil nuts (13.6 percent protein), cashews (15.6 percent), palm fruits (5.3 to 11 percent), and palm hearts (19.4 to 27.1 percent). Several of these plant foods, especially peanuts, kidney beans, Brazil nuts, and cashews, contain all the essential amino acids in proportions that compare favorably with hens' eggs, the standard measure of protein quality.

My own attempt to relate Amazonian warfare to the need to protect faunal resources has been challenged by anthropologists Napoleon Chagnon of Pennsylvania State University and Raymond Hames of the University of California at Santa Barbara. Chagnon and Hames report that the thirty-five members of the warlike settlement of Toropo-teri, a Yanomamö village located on an affluent of the Upper Orinoco River in Venezuela, consume an average of 52 grams of animal and fish protein per capita per day. This total does not include the contribution of caterpillars, grubs, termites, ants, bees, larvae, and crustaceans, which are also consumed by the Yanomamö. Since the average per capita consumption of all forms of animal protein in the United States is only about 65 grams per day, Chagnon and Hames conclude that Yanomamö warfare has nothing to do with the problem of protein production. Moreover, they point out that the Yanomamö are not the only warlike groups in the Amazon who consume large quantities of animal

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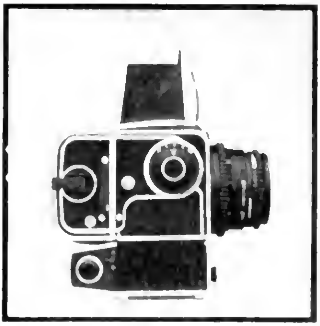

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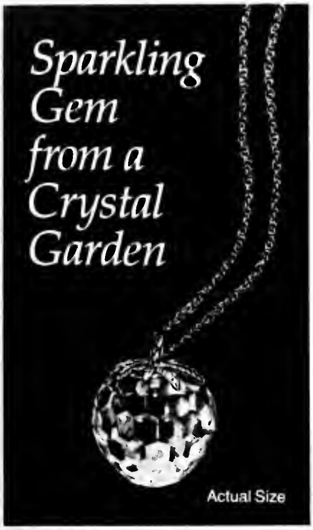

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protein. Eric Ross of the University of Michigan, for example, found that the warlike Achuara, who live along the Peru-Ecuador border, eat more than 100 grams of animal protein per capita per day.

Finally, Harner's theory of Aztec cannibalism has been severely criticized by Bernard R. Ortiz de Montellano in the pages of *Science*. "To assume that a diet requires protein from domesticable herbivores just because that is the usual American and European diet is quite ethnocentric," comments Ortiz de Montellano. There was no urgent nutritional reason for Aztecs to eat people, he argues, because they could satisfy their protein and other nutritional requirements entirely by eating 400 grams of corn, 100 grams of beans and 200 grams of native grains (*chia* and amaranth) per day. This vegetarian diet alone yields 78 grams of protein with an acceptable balance of essential amino acids. In addition, the Aztecs ate forty different kinds of waterfowl, plus armadillos, gophers, weasels, rattlesnakes, mice, iguanas, deer, turkeys, dogs, a large variety of fish, frogs, salamanders, fish eggs, water flies, water beetles, dragonfly larvae, grasshoppers, ants, and worms. (Harner himself acknowledges that Aztec commoners skimmed off the protein-rich algae that floated on the surface of Lake Texcoco and ate that too.)

I think these criticisms are based on a fundamental misconception about the need of human populations for protein. Nutritionists have mainly argued about what is the minimal "safe" level of protein intake, basing their estimates on the requirements for "normal, healthy individuals." What they fail to realize is that in cultural evolution, as in biological evolution, populations survive by being able to cope, not with what is normal and safe, but with what is extraordinary and dangerous.

The body's need for protein rises rather sharply after it has been traumatized or debilitated by infections or wounds. As explained by nutritionist Nevin Scrimshaw, chairman of the Department of Nutrition and Food Science at MIT, infections result in increased metabolic loss of nitrogen as part of a stress response: amino acids are mobilized from peripheral tissues, especially from skeletal muscles, and converted into glucose by the liver for extra energy. In addition, amino acids are sequestered for the synthesis of the antigens that provide for the body's immunological defense. "The net result of the multiple effects of infections is the need for a margin above normal protein requirements to allow for rapid repletion before the next acute episode worsens the degree of depletion," writes Scrimshaw. The need for a margin above normal is especially acute in the young, who after disease episodes may exhibit catch-up rates of growth that are sometimes five times higher than the average normal weight and height increase per day.

Since extra amounts of protein are needed for recovery from stress situations, such as those associated with illness and battle wounds, it is difficult to say what is a "safe" lower limit for a whole population. Provided that other nutritional needs are met, extra high levels of protein consumption pose no threat to health (although excessive amounts of animal fats may be undesirable). Certainly, throughout most of history and prehistory, and among the less developed countries today, the problem has always been that of too little, rather than too much, protein. Individuals and populations are therefore well advised to pursue a production strategy aimed at maximizing protein intake and at resisting any lowering of per capita norms. When one does not know what is a safe minimum, it is best to strive for the highest sustainable rate of consumption possible under given ecological circumstances. For populations subject to periodic crises of war, epidemics, and other calamities, such as storms and floods, there really is no minimum safe protein ration.

Both plants and animals contain the essential amino acids, but any specific animal food generally has more of them and in nutritionally better balance. I think this explains why there is a universal preference for animal foods—fish, meat, eggs, or dairy products—and why so many cultures do not consider a well-balanced but purely vegetarian dish to be a satisfactory meal. By insisting that at least some bit of animal protein be served along with plant foods, individuals and cultures increase the probability that protein intake will be sufficient to cope with the inevitable but unpredictable stresses of human life. Thus, the preference for animal protein is not merely a matter of arbitrary cultural taste, but a fundamental biocultural adaptation that can be surrendered only at great risk to the population concerned. We do not instinctually crave meat, but we are bio-

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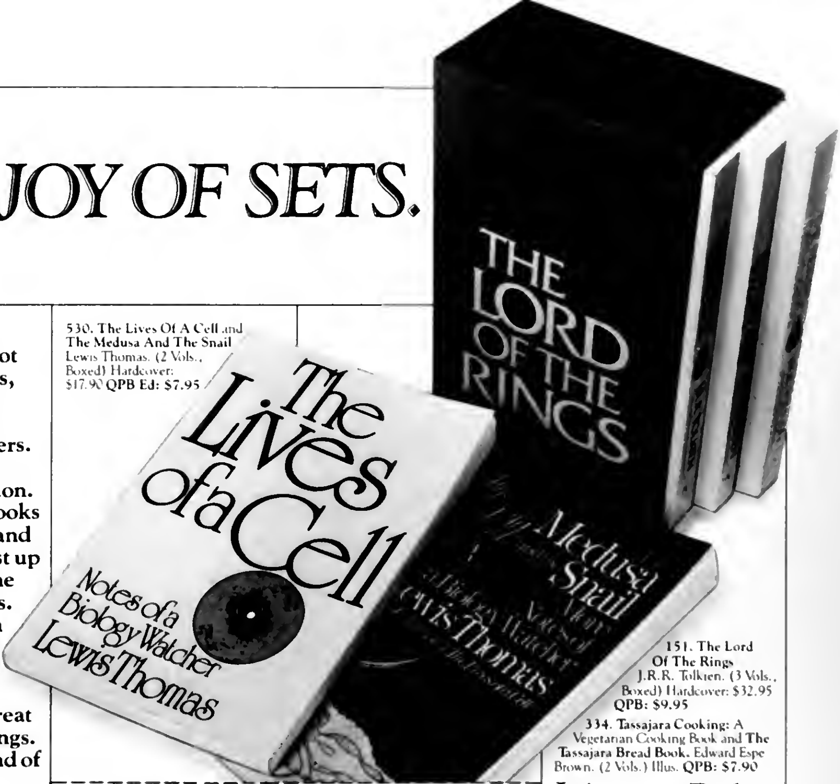

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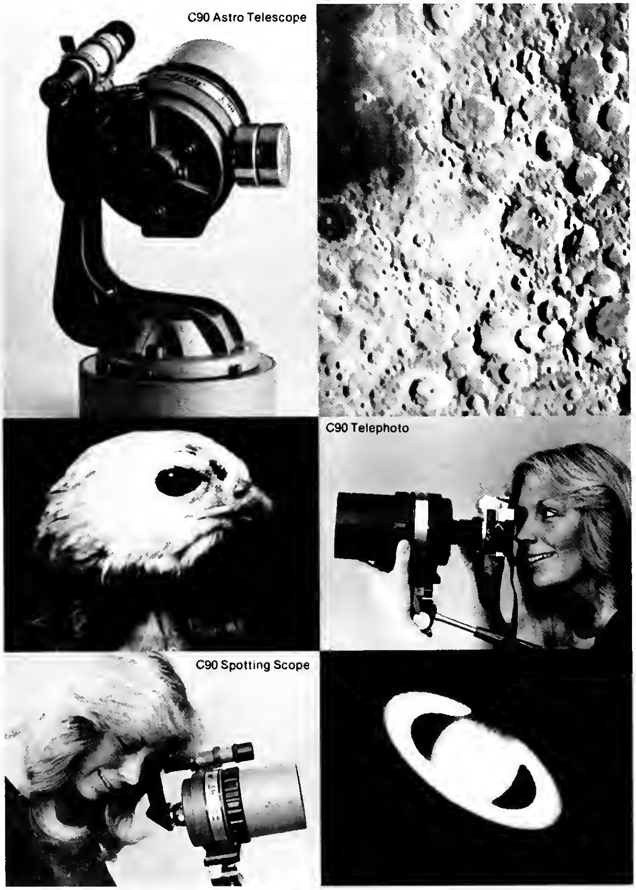

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logically and culturally conditioned to prefer animal sources of protein.

The proposal is not that the Aztec started to eat their enemies or that the Yanomamö begin to raid their neighbors' villages as soon as the per capita consumption of animal protein falls below 35 grams per day, or some such figure. Rather, what seems likely is that human populations universally strive to obtain a maximum proportion of their protein from animal sources; that they perceive a reduction in the size of their animal protein ration as a lowering of the quality of life; and that they are likely to react rather drastically in order to prevent the lowering of the animal protein ration even if it starts out as high as 100 grams per day.

While the preference for animal protein dominates the human quest for food, the proportions of animals and plants exploited and the actual animal species utilized depend on a complex balance of costs and benefits associated with food production in particular habitats. Costs in this context include how far one must walk or run to find the animals, how many men, women, and children must devote how many hours or days to hunting or taking care of them, and also any adverse effects the exploitation of a particular species may have upon other resources. Benefits consist of the net output of protein and other valuable products, as well as any secondary beneficial effects that may result from exploiting a particular species (such as protecting one's gardens from rabbits or deer).

Among hunted species, medium- to large-size animals, especially those that are gregarious, generally yield better cost/benefit ratios than small or solitary creatures. In Eric Ross's estimation, herds of peccaries, flocks of birds, troops of monkeys, and schools of fish are probably the "cheapest" sources of animal protein in the tropical forest. Carnivores such as jaguars and foxes are harder to hunt and less abundant than herbivores or insectivores and therefore more expensive.

I think this type of consideration may explain why insects, grubs, worms, caterpillars, and other small invertebrate creatures seldom, if ever, constitute the principal preferred source of animal protein for human groups. Small invertebrates are poor cost/benefit bargains because their protein comes in tiny packages, their distribution tends to be patchy, and their availability in large numbers tends to be seasonal. Moreover, small inverte-

brates are the basic food supply for many of the larger vertebrates—birds, reptiles, and fish—that provide larger packages of protein and that are better cost/benefit bargains. If larger vertebrate species are available, it makes little economic or ecological sense for inhabitants of tropical forest villages to exploit only the lowest levels of the food chain. Better to let the birds, fish, reptiles, and insectivores concentrate the protein from these tiny morsels than to do it oneself. Thus, where there is a high proportion of small invertebrates in the diet of a human group, one may reasonably conclude that it results from the depletion of large faunal resources in the habitat.

Unfortunately, there is a dearth of research on the changing proportions of species in the diet of tropical forest peoples in relationship to the size and permanency of village habitations and the intensity of faunal exploitation. The role of animal protein as a factor limiting population growth cannot be decided merely by listing alternative species. One must know how much it would cost to exploit these alternatives and whether their availability is subject to seasonal variations or to longer-term cyclical fluctuations. Even more crucial is the question of how the abundance of faunal resources is affected by long-term human predation. The law of diminishing returns predicts that exploitation of any resource cannot be increased indefinitely at the same level of efficiency. Sooner or later, each extra bit of effort will result in proportionately less output. If a group persists in intensifying its predation of fish and game beyond the point of diminishing returns, it runs the risk of permanently depleting its habitat.

All this may lend support to Harner's theory of Aztec cannibalism. In Europe and Asia the domestication of such ruminant species as cattle, sheep, and goats partly made up for the depletion and extinction of other faunal resources. In Mexico and Central America, however, the extinction of the horse, antelope, giant turtle, mammoth, large jackrabbits, and large rodents took place without other herbivores being conserved by means of domestication. The Aztecs even lacked domesticated guinea pigs, llamas, and alpacas, which provided significant amounts of animal protein for the high-density populations of Peru and Ecuador during Inca times. Ortiz de Montellano's long list of wild animals, birds, and fish eaten by the Aztecs carries lit-

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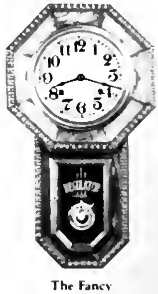

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tle weight against Harner's theory. The list merely shows that the Aztecs were willing to eat anything that swam, crawled, flew, or walked. Fish and game could not have provided significant daily amounts of animal protein to the million or more people who lived around the shores of Lake Texcoco, any more than venison can provide the principal ingredient in today's fast-food hamburgers.

What is most remarkable about the uproar that has greeted Harner's theory is the refusal to believe that the Aztecs ate people for nutritional as well as for spiritual reasons. Ortiz de Montellano and others do not perceive that the failure of most state-level societies to eat their slain enemies and prisoners of war is what needs to be explained. Surely there can be no special pride in the practice of letting millions of soldiers rot on the battlefield because of a taboo against cannibalism. One can even argue that, nutritionally, the best source of protein for human beings is human flesh because the balance of amino acids is precisely that which the body requires for its own proper functioning.

Also, in view of the law of diminishing returns, it is not surprising that the small settlements studied by Chagnon and Hames enjoy high per capita fish- and game-protein levels. This finding is consistent with the theory that such villages tend to break apart when their growth results in the deterioration of the quantity and quality of fish and game and in an increase in the cost of obtaining preferred species. To test this theory, one needs to be able to study the activities and daily diet of a village as its population grows and as it intensifies its production of animal proteins. Similarly, the relationship between diminishing returns and warfare cannot be tested by comparing the rates of hostility of small and large villages. (Small villages, threatened by large ones, must also be warlike.) To test this relationship, regional levels of population density must be studied in relationship to changes in regional levels of hostilities.

If any doubt remains as to the vulnerability of wild protein resources, one has merely to take a closer look at the rising price of fish mentioned at the beginning of this article. Despite increasingly sophisticated fishing technologies, world per capita ocean fish production has suddenly begun to decline. From 1970 to 1975 the total gross tonnage of the ocean fishing fleet of large vessels (over 100 tons) grew by more than 50 percent, but during the same period the world catch did not increase at all. As Lester R. Brown of the Worldwatch Institute points out, this means that the catch per dollar invested is falling precipitously, a classic instance of passing the point of diminishing returns as a result of overkill.

Essentially the same story lies behind the rising price of meat and other foods. During the past one hundred years or so, agronomists and agricultural economists were confident that the law of diminishing returns could be beaten by introducing ever more efficient technologies to cope with the resource depletions caused by intensive forms of agriculture and stock raising. Dramatic increases in yields per acre, for example, can be obtained by applying chemical fertilizer, and this has been the basis for much of the increase in world food output since mid-century. Yet on a worldwide basis, the amount of extra production per unit of fertilizer has been declining steadily ever since 1950. During the fifties, each additional ton of fertilizer was associated with a 10-ton increase in the world grain harvest. During the early sixties, the increase fell to 8.2 tons; the late sixties, 7.2 tons; and the early seventies, 5.8 tons. This decline has persisted right through the "green revolution," despite the introduction of new varieties of wheat and rice genetically engineered to respond to fertilizer inputs. The reason for these diminishing returns is quite obvious: the fertilizer is being applied to lands that are too arid, too steep, too stony, or in other ways ill-suited for agriculture. Farmers might overcome the declining fertilizer response curve if the cost of chemical fertilizer could be brought down proportionately. But owing to the surge in petrochemical prices, there is little prospect for such a reprieve.

We have thus already entered an era of continuously rising food prices in which animal flesh may soon become as much of a luxury for us as it was for the Aztecs. In the short run, affluent nations and classes may actually benefit from diets less rich in animal fats. But the decline in the availability of animal proteins constitutes yet another threat to the health and well-being of future generations and is certain to provoke strong and justified public reaction.

Marvin Harris teaches anthropology at Columbia University.

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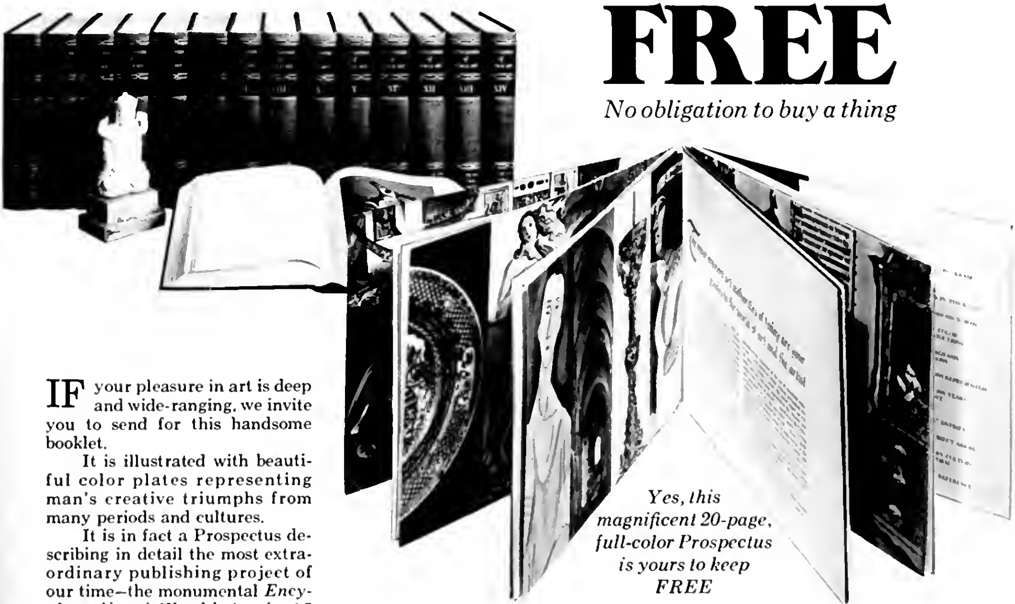

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A Petroleum–eating Bacterium

While searching for microorganisms to control pollution, investigators have found one that may be useful in cleaning up oil spills

by Irving Yall

Petroleum products are all but indispensable to our way of life. They power our vehicles, heat our homes, provide sources of protein, and furnish derivatives for the manufacture of chemicals, plastics, and fertilizer. But when they are in the wrong place—as in an oil spill—they can cause environmental damage ranging from a minor nuisance to a major disaster. A large oil spill usually gets widespread publicity. Many thousands of man-hours and millions of dollars may be spent cleaning up the results of an oil tanker accident, but the damage to the ecology of the affected area may be incalculable. Large numbers of fishes and birds may die of suffocation. Beaches may be covered with oil and tar.

Cleanup usually is accomplished by pumping the oil layer into receptacles. Contrary to popular belief, however, a substantial and troublesome portion of the oil mixes with the water. The oil-water mixture may be allowed to disperse, but many investigators are considering application of oil-consuming microorganisms to cope with this aspect of the problem. Most microorganisms cannot utilize hydrocarbons at all. Others only utilize them slowly or are very limited in the type of hydrocarbon that they attack. Several types of naturally occurring bacteria, yeasts, and molds, including one product of biological engineering by industrial researchers, have shown promise in clearing up oil spills. The microorganism I have investigated is a member of the bacterial genus *Acinetobacter*.

My research group's involvement with this organism resulted from work done on another aspect of pollution. In the 1950s and 1960s many of our lakes and inland waterways were rapidly deteriorating. They were undergoing eutrophication—a natural process that results in a lake being converted first into a swamp and eventually into dry land. In nature, these events would take at least 100,000 years to complete. Lakes such as Lake Erie, however, showed signs of going through this transformation within the next few human generations (see "The Enduring Great Lakes," a *Natural History* special supplement, August–September 1978).

Eutrophication was being accelerated by tremendous proliferations of algae caused by an excess of nutrients in the water. Two of the most important nutrients, nitrogen-containing compounds and phosphorus, came largely from man-made fertilizers and detergents. Because many of the algae involved could fix nitrogen from the atmosphere, it was useless to attempt to regulate the amount of this element entering the lakes. Phosphorus consequently became the target nutrient. Researchers felt that if the amount of phosphorus in the water could be reduced to less than one part per million, algal growth would be diminished or even completely eliminated.

Most large sewage-treatment plants in the United States depend on the use of activated sludge. In this process raw sewage is aerated in the presence of sludge containing a variety of microorganisms that hasten decomposition. The treatment should remove most disease-causing microorganisms that may be present, as well as organic matter and many inorganic substances. The effluent liquid emerging from the sludge process may be further treated with various chemicals or be diverted directly into a stream, lake, or ocean, depending upon the location of the plant.

Most activated sludge plants, however, are inefficient in removing phosphorus from sewage and so they may inadvertently contribute to the pollution of lakes and streams. To compound the problem, the use of phosphorus-containing detergents and fertilizer increased tremendously after World War II. Since the early 1970s the Federal Environmental Protection Agency has required cities in the Great Lakes region to reduce the phosphorus in their sewage effluents to acceptable levels by means of chemicals. A number of states and municipalities subsequently adopted regulations governing the use of phosphorus in detergents.

In 1969 five sewage-treatment plants located in various regions of the United States were reported to have exceptional phosphorus-removing abilities. That information immediately sparked a controversy as to whether the increased efficiency resulted from biological processes or chemical precipitation. I became principal investigator of a project at the University of Arizona (sponsored by the Federal Water Pollution Control Administration, the forerunner of the Environmental Protection Agency) that attempted to resolve the issue.

We decided to study the activated sludge from one of the above-mentioned plants—the Rilling Road Plant

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The white areas inside these Acinetobacter phosphadevorus *cells are hydrocarbon inclusions.*

in San Antonio, Texas—and compare that plant's ability to remove phosphorus from sewage with that of the Tucson sewage-treatment plant. We found that the Rilling Road sludge removed phosphorus very effectively from Tucson sewage and concluded that the removal was biological in nature. The next step was to isolate the one or more organisms responsible.

Our first attempts involved "shotgunning," that is, isolating as many different types of microorganisms as possible from the Rilling sludge and testing their individual abilities to take up phosphorus. None of the hundred or so species of bacteria and other microorganisms tested, either singly or in combination, accounted satisfactorily for the superior phosphorus-removing ability of the Rilling sludge. We then tried another approach, an attempt to localize the phosphorus taken up by the sludge mass.

First, we looked within the cells of algae and other microorganisms for a granular, phosphorus-containing substance named volutin. Microorganisms that accumulate phosphorus in excess of their metabolic needs frequently incorporate it into volutin. When appropriately stained, volutin granules appear violet or blue under a bright-field compound microscope. Examined in this fashion, the stained Rilling sludge showed clusters of bacterial cells of a distinct morphology containing numerous volutin granules.

Next we had to show that these volutin-staining regions did indeed contain phosphorus from the sewage. We allowed the sludge mass to take up phosphorus-33, a radioactive isotope, then placed the radioactive particles on microscope slides and covered them with a liquid photographic emulsion. After exposure of approximately one month, we developed the emulsion and looked for fogging. Fogging in localized areas of the sludge mass would indicate a concentration of the radioactive phosphorus. We were pleased to find that phosphorus-33 was present primarily in the sludge areas that were volutin positive.

We knew now that the phosphorus in the sludge was localized in a spherical bacterium about one micrometer in diameter that seemed to occur in grape-like clusters. One of our staff undertook to isolate an organism of that description. It took him six months before he succeeded in obtaining a pure culture that we referred to as isolate P 7 and subsequently placed in the genus *Acinetobacter.*

P 7 was unusual in that it synthesized volutin early in its life. Most bacteria that form volutin do so in old cultures that have a nutritional deficiency. By contrast, P 7 formed volutin granules almost immediately upon transfer from an old to a new culture. When the microorganism was added to Tucson sludge, it increased the ability of the sludge to remove phosphorus from sewage by a factor of approximately 16. In view of its phosphorus uptake ability, P 7 was unofficially named *Acinetobacter phosphadevorus.*

Further investigation disclosed other interesting metabolic characteristics of P 7. It could use a wide range of hydrocarbon compounds as sources of carbon for growth. In sewage, it seemed to live on such volatile acid hydrocarbon fractions as acetate. However, it could utilize carbon compounds with chain lengths that ranged from the shortest, C-1—containing a single carbon atom—to at least C-40, the very long, containing forty carbon atoms. It could use many of the common alcohols, acids, and amino acids, but could not grow on such alcohols as the sugars. It grew especially well on saturated hydrocarbons.

We tested various mixtures of pure hydrocarbons, ranging in chain length from C-12 to C-40; P 7 seemed to prefer compounds of C-12 length when they were present. Otherwise, the microorganism did not discriminate among chain lengths but accepted whatever was offered, accumulating the hydrocarbon in droplets within its cells.

The ability to utilize a wide range of hydrocarbons makes P 7 a unique organism. The metabolism of most bacteria of this type is confined to a relatively restricted range of hydrocarbon chain lengths. Because of P 7's special capacity, we decided to investigate the organism's power to clean up the hy-

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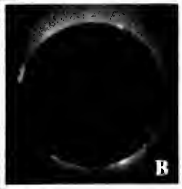
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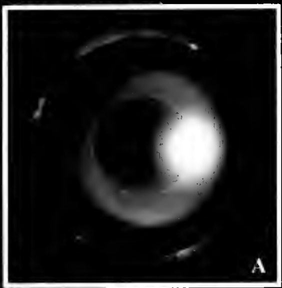
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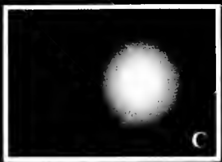
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drocarbons that are associated with oil pollution.

Our first series of experiments exposed Tucson sewage containing motor oil to Tucson sludge seeded with P 7. Most sludges cannot cope with an influx of oil or similar products. When oil or kerosene is introduced into a sewage system, it inactivates the sludge plant if it reaches it. Our system started to break down the oil immediately. The bacterial cell mass in the seeded sludge grew to about ten times the amount obtained from sludge treating sewage without the oil. The increase in mass was due to the proliferation of P 7.

Within three days, the amount of oil present in the sewage dropped below the level of detection by the analytical methods employed. Disappearance of the oil was found to be dependent on the amount of inorganic substances present, especially nitrogen and phosphorus. As the oil level dropped, so did the amount of phosphorus. Oil uptake stopped when the amount of phosphorus dropped below detection levels. When oil was completely removed from the system, the sewage alone was unable to support the large cell population. As a result many cells underwent destruction and released relatively large amounts of phosphorus into their environment. Our experimental system using P 7 can apparently cope with daily influxes of oil and sewage. That should make the organism serviceable in situations where oil or grease is introduced periodically into wastewater.

We decided to investigate the possible application of P 7 to a marine environment. The organism can grow in synthetic, laboratory-produced seawater but does so more slowly than in a freshwater environment. It was able to utilize 80 percent of a hydrocarbon of the paraffin series in synthetic seawater with a concomitant reduction of phosphorus in approximately ten days. The main problem as far as the marine environment is concerned seems to be a lack of adequate amounts of phosphorus, and possibly nitrogen, which P 7, like all microorganisms, needs to grow on.

We are currently investigating the ability of P 7 to cope with Texas crude oil in both freshwater and saltwater environments. P 7 can grow in both environments when crude oil is the sole source of carbon; however, additional sources of nitrogen and phosphorus have to be provided.

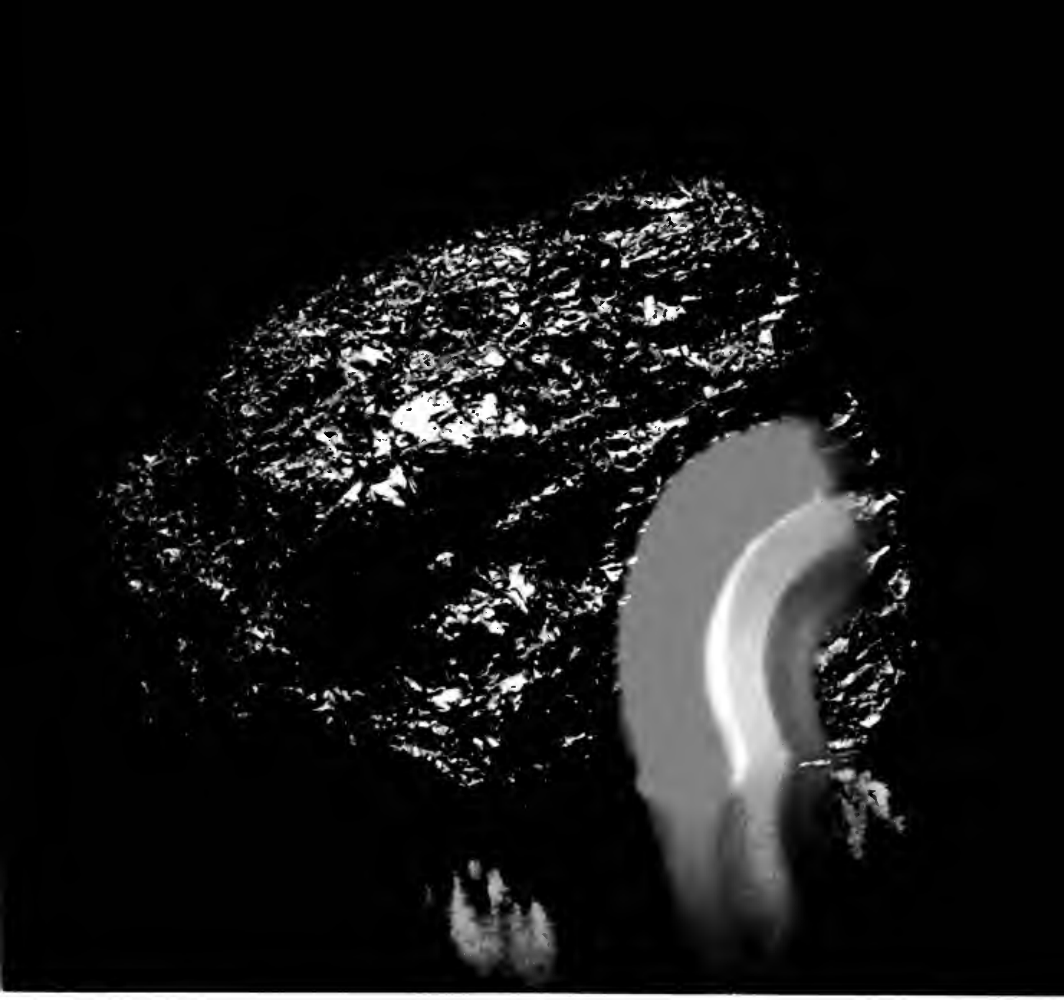
Our early results with Texas crude oil in freshwater have been very encouraging. When nine grams of crude are placed in 6-liter (1.6 gallon) reactors containing P 7, the oil is rendered completely soluble in one day. Sixty percent of it is removed within three days, and 85 percent is gone by six days. The only material readily apparent after this time is cells and cell debris. We are experimenting with the amounts and sources of nitrogen and phosphorus to be added to the oil in the belief that the proper inorganic balance will lead to faster oil removal.

Much of our activity during the past year has concentrated on the effects of P 7 on animals and plants that may be present when the microorganism is released into an environment containing a hydrocarbon. We were especially concerned with the effects on brine shrimp, other filter feeders, and fish that might ingest the organism when it contained hydrocarbon inclusions. We have now completed our study on marine life and found no deaths or diseases that could be attributed to the P 7, even though its cells could be isolated from the gut of the various animals. Studies on freshwater organisms currently under way show similar results.

Many bacteria that exhibit a pronounced ability to utilize oil and other hydrocarbons possess particles within their cells called plasmids. Plasmids contain genetic material that endows the cells with abilities they would not otherwise have. Some plasmids can be transmitted from one cell to another and can thus be used in genetic engineering to modify various organisms.

One of the projects currently under way in our laboratory is a genetic study of P 7 to determine whether or not plasmids are present. We hope eventually to obtain an organism that has improved ability to utilize oil and phosphorus and that can function at 60°F instead of the approximately 80°F temperature range of the present organism. An organism that can utilize oil at lower temperatures could be very useful since many spills occur in cold waters, such as those off the coasts of Nova Scotia and Alaska.

All the results mentioned in this article were obtained under laboratory conditions. Further tests, on a larger scale and under field conditions, are necessary before P 7—*Acinetobacter phosphadevorus*—can be regarded as anything more than a laboratory phenomenon. □



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River Blindness

Some fifty million people suffer from this horrendous disease

Information has reached me that the village of St. Pierre has disappeared; all that is known of it is that the houses are completely deserted and broken down.
A. Rolland, 1972

In 1963 a small band of settlers, driven by hunger, left their overpopulated and infertile land in the savanna of West Africa and migrated to the banks of the Keralie River, a tributary of the Black Volta. There, they built the village of Saint Pierre and began to farm the rich valley land.

Five years later, 75 percent of these pioneers had developed ocular lesions. Some were already functionally blind. Finally, life and sight became too precarious and they fled. By the time epidemiologist A. Rolland made his report, Saint Pierre had become still one more ghost town of the West African savanna: another community crumbled by the parasitic filarial worm *Onchocerca volvulus* and its vector, the blackfly *Simulium damnosum*.

The disease onchocerciasis, familiarly known in Africa as river blindness, has a quality of Gothic horror not shared by other tropical infections. Malaria decimates the young but usually leaves the survivors sufficiently immune to be a productive support of their community. Trypanosomiasis denies vast areas of Africa the benefits of mixed farming and the protein that could be provided by domestic animals, but basic agriculture is rarely disrupted, and except for sporadic outbreaks, the prevalence of human sleeping sickness is now low. Onchocerciasis, in contrast, dispossesses man from the most fertile agricultural land and blinds those who would dare tenant its dominion.

The victims are rural peasants, too often neglected by the political, medical, and technological panjandrums concentrated in the great cities. Therapy by the few effective drugs available can be worse than the disease. Control of the blackfly vector is so costly and demanding that it is beyond the capabilities of most of the affected third world nations. The disease afflicts at least fifty million people; yet since it doesn't kill, only a handful of scientists have pursued research into combating the parasite and its vector.

The major storm center of onchocerciasis is West Africa, but pockets of infection also exist in East Africa, Yemen, and in the New World from Mexico to Brazil. Infected West African slaves, met on arrival by indigenous species of blackfly, probably introduced the disease into the Americas. As early as 1590, more than a thousand slaves were imported annually from endemic areas of West Africa to work the placer gold mining operations in Colombia and Venezuela. The alluvial-bedded streams carrying gold were also ideal breeding habitats for the blackfly, and the infection, established almost 400 years ago, persists in these remote areas.

The final import into Mexico was not by slaves but through a French military adventure. In 1862 Napoleon III sent Sudanese troops to Oaxaca to assist the French invasion forces. These Sudanese came from an area where onchocerciasis is still prevalent, and according to Mexican historians, signs of infection turned up not long after the troops arrived. These focuses of disease exist today in the Mexican and Guatemalan highlands at an altitude of 1,600 to 5,000 feet, where the main blackfly vector, *Simulium ochracaeum*, breeds in the mountain streams. This is also the altitude where the coffee plantations are situated, and the bitterness of that epidemiological brew is that 30 to 75 percent of the plantation workers are infected with the parasite. The current cost of some of our favorite "mountain-grown" coffee is indeed high; not only in dollars per pound but also in atrophied skin, itching eruptions, eye disorders, and blindness.

The filarial nematode that causes river blindness is a first cousin to the filaria parasites that produce the notorious elephantiasis with its grotesque disfigurements of limbs and genitalia. The adult worms are threadlike creatures that live encapsulated within fibrous nodules beneath the human skin. In common with all filarial worms, the eggs hatch before they depart the uterus as microscopic, snakelike larvae, the microfilariae. Each female worm can birth 2,000 or more microfilariae every day of the fifteen to twenty years of her life within a human. Upon leaving the mother, the microfilariae disperse to the upper layers of the skin and other parts of the body, including the eye.

The next act in the biological scenario takes place when the biting blackfly ingests microfilariae while feeding. Within the blackfly, the parasite passes through a series of transformations, first within the gut, then in the muscles of the thorax. After a final metamorphosis into a slender, filariform larva (the infective stage), it migrates to the head and mouth parts. This cycle takes about two weeks. The filariform larvae escape when the blackfly bites a human; they enter the subcutaneous tissues, grow to adults, and mate. About nine months later the females begin shedding the microfilariae.

When I was what now seems a very young junior officer in the then Nigerian Colonial Medical Research Service, I used to spend my local leaves fishing for the tiger fish, that splendid warrior of the African rivers, and the "elephant of the waters," the Niger perch, on the Gurara and Benue rivers. I recall wondering—with the innocence and narrow interest of youth (I was "into" sleeping sickness in those days)—why so many of the locals who accompanied us on those

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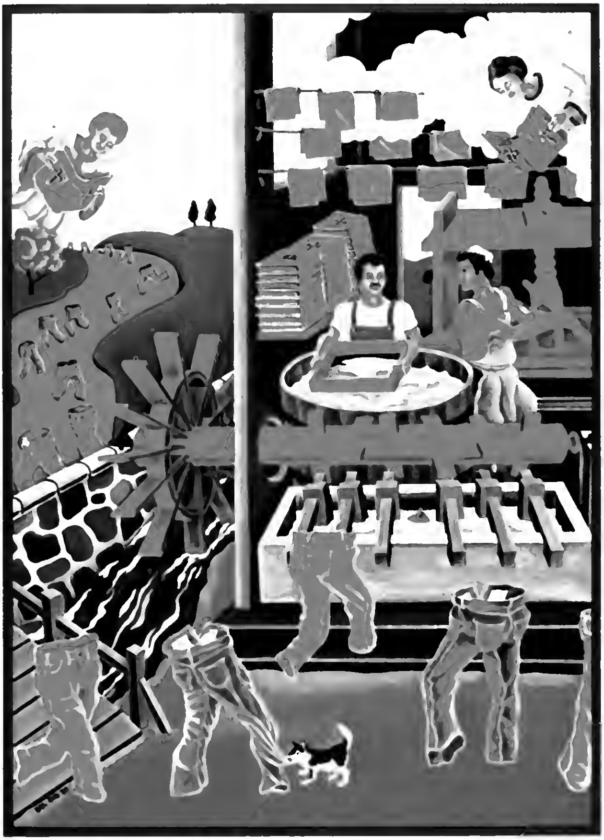

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trips looked so old. It seemed a cruelty that the chiefs would send these ancients to bear our loads.

I realize now that most of these "ancients" were probably not much older than I and had been propelled into premature senility by the *Onchocerca* microfilariae in their skin. Some fifty years ago, a physician working in the Sudan commented that "onchocerciasis makes young people look old and old people look like lizards."

The microfilariae incite a chronic inflammation of the skin tissues, accompanied by an itching so intense that some of the afflicted have been driven to suicide. In time, the normal architecture of the skin vanishes, replaced by a toneless, thickened, depigmented covering—the pachyderm skin. The skin over the groin may become so loose as to hang down as a kind of bizarre apron. The lesions in the eye, however, produce the most serious consequences of onchocerciasis. As the microfilariae invade the cornea, anterior chamber, retina, and even the optic nerve, the mechanical damage and inflammatory response of the immunologically "outraged" host can lead to partial loss of sight and, eventually, total blindness.

The clinical end products of infection have been well characterized, but the mechanisms underlying their pathogenesis are dimly understood. They apparently involve the human immune system. The level of functional immunity is relatively low despite the production of high levels of antibody. The host's cellular reaction to the dying microfilaria is more severe than to the living one (possibly, like some other parasites, the living microfilaria is masquerading, antigenically, as a human). We have a glimmer that in the worst cases part of the immune system may be depressed, and this has led to the suggestion that the pathological "entity" may be a conjugate of the human antibody and antigen released by the dying worms.

One reason why we have little more than glimmers, suggestions, and hypotheses surrounding pathogenesis and immunity is the absence of a satisfactory experimental model. The parasitic worm is steadfastly devoted to its human host and refuses to infect any conventional laboratory animal. Humans in endemic areas are generally inaccessible and naturally cannot, or should not, be manipulated for experimental purposes. A related species of nematode, *Onchocerca gutturosa*, infects cattle. The pathologic picture differs from that in man, however, and at any rate, the cow is not exactly the most available animal for laboratory-based scientists, especially those working within the limitations of current research budgets.

Different ecosystems have sibling species of different character, of both parasite and blackfly vector. For the biologist, the observation of these fascinating variations is like being a spectator at a game of evolution played out on a gigantic scale. For the clinician and epidemiologist, this incipient speciation has considerable practical importance.

Variations in the clinical expression of infection in humans raised the first suspicions that the parasites of the humid forest and the savanna might be different, despite their identical morphology. Infection rates are generally very high among forest dwellers, in many instances higher than among people living in savanna communities, yet severe optic pathology is unusual. One study showed that in forest people the rate of eye disease was 4 percent, while it was 34 percent in the savanna village examined, despite a similarity in infection rates. Infected forest people do not escape unaffected; the other manifestations, such as skin lesions and thickening, are all there.

Two English workers, B.O.L. Duke and J. Anderson, have provided a degree of experimental confirmation that the forest and savanna parasites differ in their virulence. Microfilariae obtained from savanna patients were more invasive and produced more severe optic lesions in rabbits than did microfilariae obtained from forest patients. More recently, another English group, led by Anthony Bryceson, found distinct differences in antigenic composition between parasites of forest and savanna origins.

The major African blackfly vector, *Simulium damnosum*, has also evolved separate ways in the forest and savanna. Again, behavioral differences were the first clues of incipient speciation. For example, the smell of humans primarily attracts the forest blackfly, while the sight of humans, rather than odor, impels the savanna blackfly to feed. By classic morphological criteria, all *S. damnosum* are identical, but an elegant new technique, cytotaxonomy, has revealed that, in fact, this blackfly has evolved to a complex of species. An examination of the giant polytene chromosomes in the salivary glands—by experts who can read their distinctive pattern of bands like a road map—revealed that forest and savanna blackflies were two separate species. This speciation of both parasite and vector within the two ecosystems has also led to a lack of reciprocity in vector–parasite relationships. When blackflies captured in the forest were fed on onchocerciasis patients from the savanna, no infection developed in the blackfly. Nearly all the microfilariae were rapidly destroyed while still inside the blackfly's gut.

For the human voyager, "getting there" may be half the fun if one can believe the blandishments of the travel industry, but for the vector-borne parasite, getting there is essential for survival. The habitat and behavior of the vector largely determine if the parasite will successfully make the crucial journey from host to host. In common with most insect vectors, blackflies are highly selective in their breeding habitat; this restriction is fundamental to the epidemiology of onchocerciasis.

The female blackfly deposits her eggs only in fast-flowing, well-oxygenated water containing sufficient organic debris to nourish the filter-feeding larvae. These larvae attach to stones, aquatic vegetation, or limbs of trees dipping into the water (one East African species has developed the curious habit of attaching to the back of freshwater crabs). From these breeding sites, the emergent adult blackflies disperse for many miles into the surrounding bush, where they make a formidable barrier, denying the fertile river valley to human settlement and agriculture. In endemic areas, infection rates begin to decline only beyond a distance of up to ten miles from the river.

Unfortunately, human attempts to exploit the riverine land often initiate a tragic cycle. Before human settlement, the rivers and streams usually run clear, providing an insufficient amount of suspended organic matter to maintain a large population of blackfly larvae. Where adult blackfly density is low, human population increases through normal growth and immigration into the sparsely inhabited riverine bush. Land use intensifies deforestation. In these highly cultivated watersheds, soil erodes and the land loses its ability to hold rainfall. River courses and flow patterns change. During the wet seasons, the once clear rivers carry enormous amounts of suspended organic matter—creating ideal condi-

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tions for the prolific breeding of blackflies.

Biting increases to such a degree that each person may receive 50,000 infective-stage larvae each year. The attack of flies alone is almost unbearable (readers who have suffered blackfly bites while flogging our northern trout streams can sympathize with the plight of the African). The onset of eye lesions finally destroys the community. In time the people abandon the village and retreat to the arid savanna or the equally arid fly-free highlands. There they rapidly deplete the soil in a futile attempt to feed themselves. Starvation drives them back to the river, and generation after generation is yo-yoed between hunger and blindness.

Grandiose hydroelectric schemes have had both a beneficial and a harmful effect on onchocercal endemicity. To be charitable to the master builders, the lakes they have created behind the dams obliterated stretches of river where blackflies formerly bred. The huge, man-made Lake Volta in Ghana relieved an area 200 miles long of the fly. (Unfortunately, charity must end with onchocerciasis. This same lake created a marvelous 4,000-mile shoreline to contract the blood fluke *Schistosoma hematobium*, and as the lake filled, the prevalence of this parasite in the schoolchildren of some lakeside villages soared from one percent to 100 percent.)

Below the dams, the transmission of river blindness often intensified. The kilowatts that lit the cities extinguished the light for thousands of rural inhabitants. The largest dams with the largest lakes, such as the Volta scheme, have a constant flow of water over the spillways. Not only does the blackfly breed in the courses below the spillways, but now continuous water flow permits perennial breeding and causes perennial transmission of the disease. The natural cessation of river flow in the dry season, which once brought about a drastic diminution of the vector population, no longer occurs.

The remedy for onchocerciasis may perpetuate ecological imbalance. The obvious solution to the problem is to eliminate either the vector or the parasite. The main effort has been to reduce blackfly breeding to a level where little or no transmission occurs. Alarmed by the havoc of onchocerciasis in the Volta River basin, an international consortium led by the World Health Organization, and bankrolled by the United Nations Development Program to the tune of $120 million over a 20-year period, is trying to do just that.

The method of control has been to apply DDT and other insecticides to the breeding waters. However, the parasite is long-lived in humans, fifteen to twenty years, and to eradicate the infection, long-term application is required, until all the microfilaria carriers become "burnt-out" cases. This strategy requires that insecticides be infused into the water for twenty years. The insecticides kill not only the blackfly larvae but also their natural predators. If control measures are halted prematurely, unrestrained recolonization may occur, followed by even more intensified transmission. This has, in fact, happened at least once, in the Ivory Coast.

The option of mass drug administration against the parasite is also foreclosed because the sole microfilaricidal agent available, diethylcarbamazine, produces adverse reactions so severe as to preclude its use except under careful medical supervision. Diethylcarbamazine, or DEC as it is known in the trade, is the workhorse of antifilarial compounds. Despite its usage for forty years, virtually nothing is known about how it acts on the parasite. One can take microfilariae, put them in a test tube containing a solution of DEC at high concentration, and watch them continue to wiggle about in lively fashion. Yet the microfilariae die quickly in the treated patient.

The current theory holds that the drug changes the parasite in some unknown way to allow the host's immunologic system to destroy it. Whatever its mode of action, DEC is effective. It is also cheap. It is also damnably toxic, and this too has remained an unsolved mystery. DEC is perfectly safe and nontoxic when given to an uninfected person. When an individual with filariasis takes the drug, however, an adverse reaction develops, ranging in severity from headache and fever to death from an allergiclike shock syndrome. DEC treatment of the other forms of filariasis, such as the Bancroftian and Malayan lymphatic types, rarely produces severe adverse reactions. But in posttreatment onchocerciasis, a pruritic rash will occur, accompanied by a fall in blood pressure and occasionally the collapse of the patient. While the symptoms may seem like the result of a giant bee sting in a hypersensitive individual, the reaction is not a typically allergic one because antihistamines fail to block it.

My colleagues and I, intrigued by this phenomenon, have been experimentally chipping away for the past several years in an effort to understand the underlying cause of the reaction and to acquire a means to prevent it. We have used, as a model, the only form of animal filariasis in which DEC may initiate a side reaction so untoward as to be fatal—the dog infected with the dog heartworm. So far we have only bits and pieces of small, tantalizing insights. When the infected dog becomes distressed an hour or two after being given DEC, the antibody in its blood disappears almost completely. In some dogs the IgE "allergic" antibody goes, while in other dogs the IgG precipitating antibody disappears. The dog's temperature rises, blood pressure falls, the liver has a *crise de fois*, and the number of platelets, those small, round cells in the blood intimately involved in the coagulation process, plummets. The substance or substances responsible for this pathologic cascade have defied isolation so far.

One hypothesis is that the reaction somehow arises from the complexing of antibody with the worm antigen. A blackboard in my laboratory has lists of all these findings and arrows that show the possible pathways and relationships. From time to time a graduate student or visitor will contemplate this *Gemisch* of data and draw in another line. The blackboard has begun to look like a Jackson Pollock painting. Meanwhile we are experimenting empirically with known blocking agents that act on certain pathways, hoping that chance will favor our prepared minds. We are not even certain the events that occur in the dog also occur in the treated human. But at least we have some idea as to what to look for when we move from the laboratory to field and stream.

In one of his more enlightened manifestos, Lenin once exhorted *Devastate the Worms!* But the revolution, in the form of more effective and safer drugs and larvicides, is yet to come for the tropical proletariat under the yoke of onchocerciasis. Until that jubilee day, means will have to be found to implement the measures now available, and the planners of great schemes will have to adopt the physician's guiding principle: first do no harm.

Robert S. Desowitz teaches tropical medicine at the University of Hawaii at Manoa.

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WINNERS OF THE 1979 NATURAL HISTORY PHOTOGRAPHIC COMPETITION

"How fleeting are the wishes and efforts of man! how short his time! and consequently how poor will his products be, compared with those accumulated by nature during whole geological periods." To Darwin, at least, natural selection was a mechanism more wonderful than human choice. But both are essential to our Photographic Competition. Although nature may propose the subject matter, photographers compose, and judges dispose.

The variety of entries submitted in each of our four categories—The Natural World, A Sequence of an Event in Nature, Photomicrography, and The Human Environment—gave evidence of the creative choices made by our contestants. Some were determined to wrestle with volatile or intractable material and must have been glad finally to achieve one usable photograph. Others, blessed by opportunities, no doubt found that the toughest decisions came in staying within our limit of three entries per category.

Of the many photographs screened, approximately four hundred survived to become finalists in the formal judging. Presiding this year were three experienced photographers: John Dominis, former staff photographer at *Life* and currently the picture editor of *Sports Illustrated*; Burt Glinn, a photographer with Magnum, the international photo cooperative, and a member of the executive committee of the American Society of Magazine Photographers; and Arthur Rothstein, director of photography for *Parade*, the Sunday newspaper magazine, whose most recent book, *The Depression Years*, was published in 1978. Balancing various criteria—technique, originality, subject interest, artistic merit—our judges reached consensus on the winners, awarding this year's Grand Prize to a photograph with human content. A First Prize was given in each of the four categories; there were, as well, a total of ten Honorable Mentions and one Special Award for Humor in Nature.

In terms of numbers of finalists, competition was greatest in the broad Natural World category, whereas relatively few photo sequences were considered. And no entry was found to merit a Special Award for Urban Wildlife. Entrants in next year's contest may want to keep these facts in mind; the rules and deadline for participation will be announced in a future issue of *Natural History*. Meanwhile, we hope you enjoy viewing the 1979 contest winners, which will also be exhibited at the Museum this fall.

Vittorio Maestro

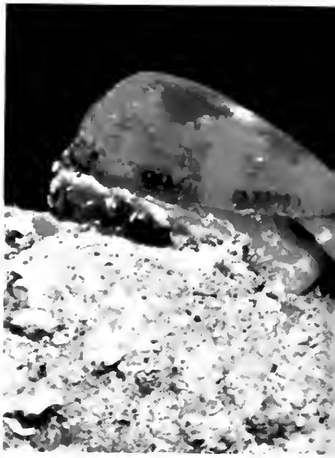
GRAND PRIZE

Shelley Rotner

While traveling for pleasure and photography in the fall of 1977, Shelley Rotner passed through the Guatemalan town of San Pedro on Lake Atitlán. There she met some people weaving and, with permission, photographed three children on an unusually colored, semienclosed porch. Rotner recently received a master's degree in elementary education and museum education from the Bank Street College of Education in New York City.

FIRST PRIZE
The Human Environment
Jeff D. Nicholas

This ghostly, junked car, resting on the coastal rocks of Pacifica, California, was photographed late in the afternoon of a foggy day. What appears to be mist, however, is actually the ocean and ocean spray recorded using a long (8-second) exposure. Jeff D. Nicholas, who lives in Palo Alto, California, manages a retail store for natural history related objects and materials.



FIRST PRIZE
A Sequence of an Event in Nature
Alex Kerstitch

Alex Kerstitch was photographing the territorial behavior of a goby when it fell victim to the appetite of a cone shell snail. The initial reluctance of the fish to flee suggests it may have been a male guarding eggs. In the sequence, the cone shell first locates its prey by smell, using its proboscis (the orange tube). Then it shoots a small, poison-filled arrow (invisible to the naked eye) through the proboscis, paralyzing the fish. In a few minutes, the snail's distended mouth envelops the meal. Digestion may take twenty hours; indigestible material is then released. The photographs were taken in the Gulf of California, western Mexico, using a Canon F-1 camera equipped with a macrozoom lens and a Plexiglas case. The strobe was a Subsea 150, one foot away; the film, Kodachrome ASA 64; the exposure, f-22 at 1/125 second. Alex Kerstitch is a research associate in the Department of Ecology and Evolutionary Biology at the University of Arizona, Tucson, and teaches high school art and science.



FIRST PRIZE
The Natural World
Robert Becker

Having spotted this lone tree in the pink sand, Robert Becker circled it carefully so that his footprints would not intrude. The photograph was taken in Utah's Coral Pink Sand Dunes State Reserve, August 1978. Becker, an engineering manager in electronics manufacturing, lives in Northridge, California.

FIRST PRIZE
Photomicrography
James Hanken

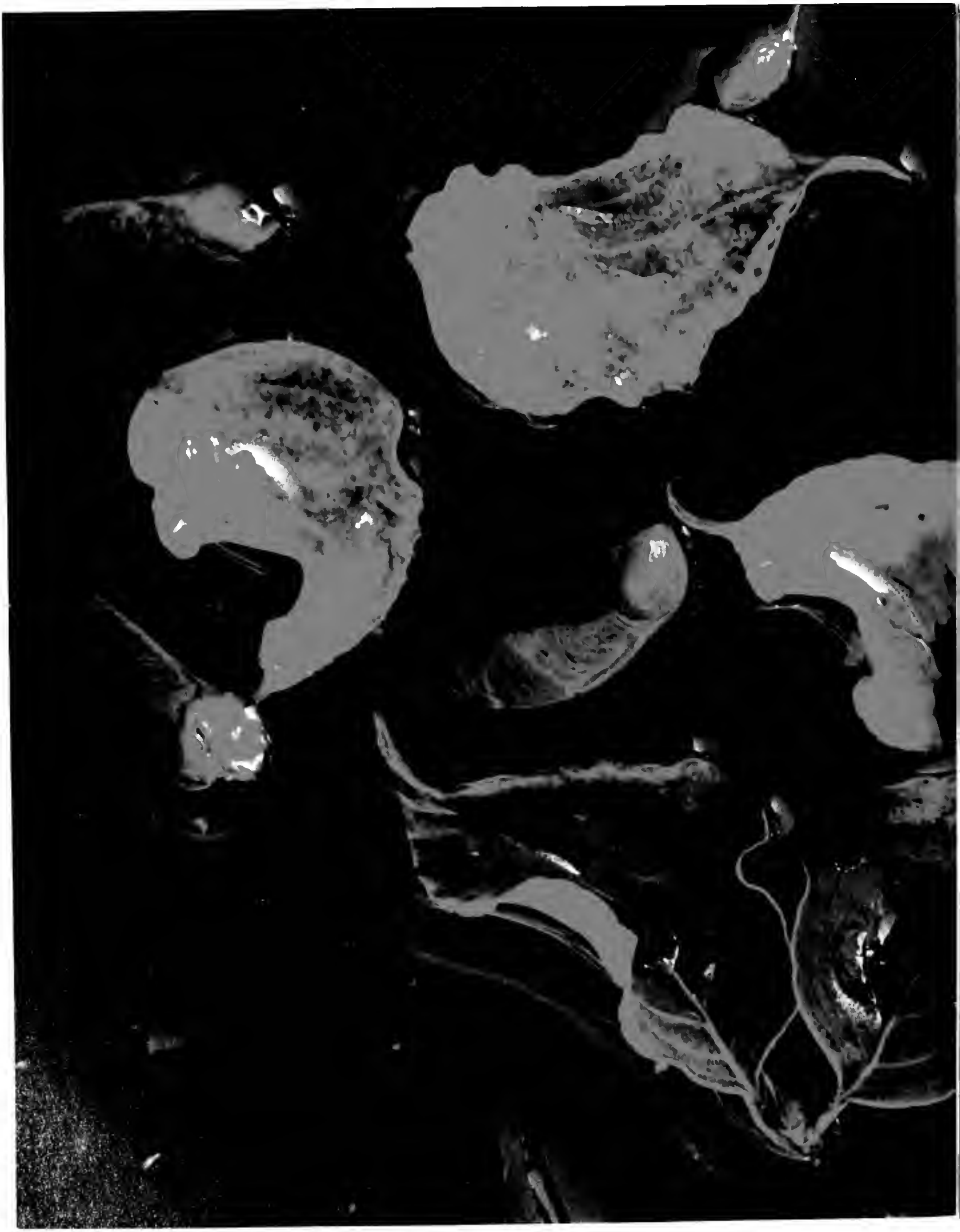
*A human resemblance is apparent in this three-quarters developed embryo of a long-legged bat (*Macrophyllum macrophyllum*). To show ossification, bone is stained red, cartilage blue; undigested yolk in the belly area is an opaque yellow. The 20X photomicrograph was made with a Wild zoom stereomicroscope. James Hanken, who is a graduate student in the Department of Zoology at the University of California, Berkeley, specializes in evolutionary biology and salamanders.*

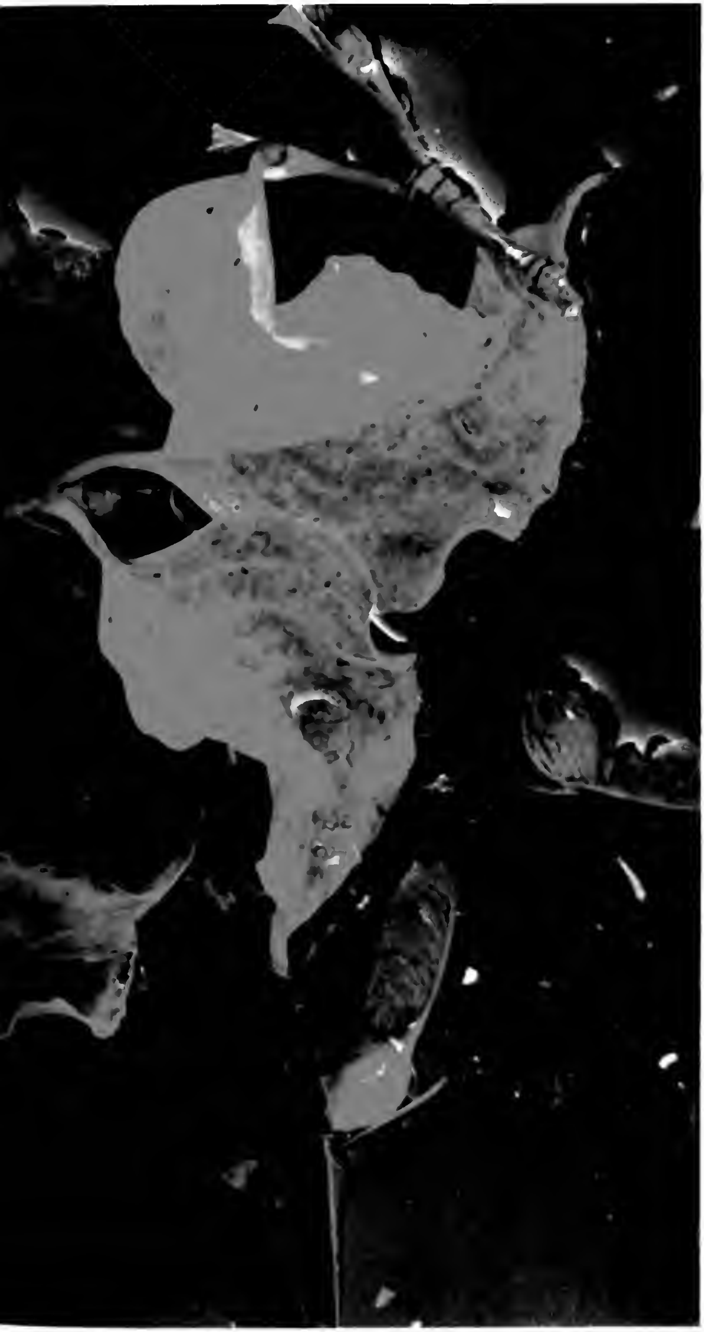
SPECIAL AWARD
Humor in Nature
GENE BURNETT

These African dwarf chameleon babies were two of more than a dozen unexpected bonuses that Gene Burnett got when he bought an adult pair as pets. The photographer, a resident of Evanston, Illinois, works in a pet store; he cautions that these creatures are rarely raised successfully in captivity.

HONORABLE MENTION
A Sequence of an Event in Nature
WILLARD COLBURN

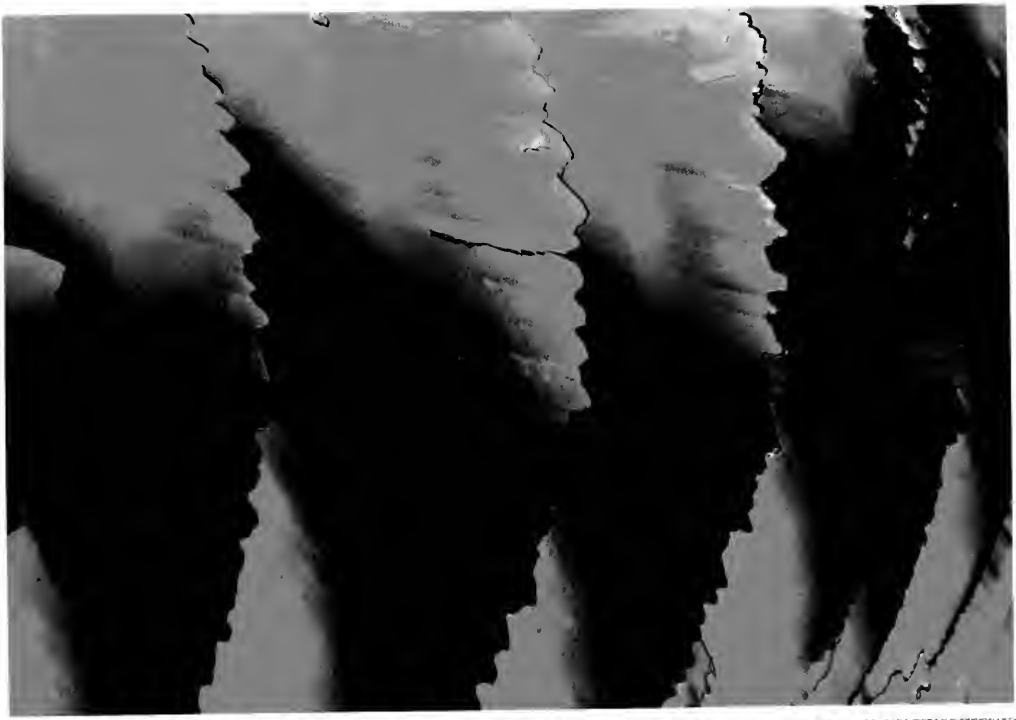
Hoping to observe the butting that characterizes the sheep mating season, Willard Colburn traveled to a chilly Yellowstone National Park (Montana) in November of 1978. Although not keen on butting, the sheep did provide him with this sequence, photographed from 100 feet away with a 500-mm lens. Colburn is a house-painting contractor in Eugene, Oregon.





HONORABLE MENTION
The Natural World
LAWRENCE SCHAEFFLER

Last autumn's leaves stood out brightly on the photographer's blacktop driveway in Fredonia, New York. Retired as chairman of piano in the music department of Fredonia State Teacher's College, 86 year old Lawrence Schauffler is also accomplished in photomicrography.



Honorable Mention
Photomicrography
Suzanne Groet

Photomicrography is a hobby for Suzanne Groet, a botanist from Lincoln, Massachusetts. Pictured here is a urea "melt crystal," formed when a crystal is melted and allowed to recrystallize on the slide. A Leitz Ortholux microscope provided 20X magnification, and polarized light was used.

Honorable Mention
The Natural World
Michael J. Nigro

Living in Gustavus, Alaska, Michael J. Nigro is a free-lance photographer as well as a park ranger at Glacier Bay National Monument. He found this stranded subtidal starfish on the shore of Lituya Bay on the Gulf of Alaska. This one measured about one foot across, but specimens more than a yard wide have been recorded.

Honorable Mention
Photomicrography
Per Haack Kjeldsen

Although it was peripheral to his work, this specimen of the bony labyrinth of the human inner ear fascinated Per Haack Kjeldsen, a biomedical photographer at the University of Michigan School of Dentistry. A lens with a luminar type microoptic enlarged the subject about two and a half times. The color came from red and blue gels on the two strobes, which were flashed eight times while the shutter was left open.

HONORABLE MENTION
The Natural World
TOM DUERST

High school teacher Tom Duerst, with his brother's help, started seven years ago to develop a system to photograph hummingbirds. Flies proved easier to attract to his backyard in Eau Claire, Wisconsin. In this photograph, the subject was pinpointed by a photoelectric trigger consisting of two intersecting light beams. Duerst used an external shutter with the camera's own shutter left open, Kodachrome 64 film exposed at 1/25,000 second, and four flash units, three on the fly, and one on the background.

Honorable Mention
The Natural World
Mary Koga

This wildflower, an orchid called lady's slipper, or moccasin flower, was bathed in the diffused light of a window. Mary Koga, a free-lance photographer, currently teaches part-time in the photography department of Chicago's Columbia College.

Honorable Mention
The Natural World
John D. Harford

On a dark winter's day in upstate New York, this titmouse was caught in flight near the photographer's garden bird feeder. Although Harford realizes "there are better ways"—with fancier equipment—he persisted with his prefocused Canon AE-1 camera and flash until he got lucky. A professor of economics, Harford willingly concedes he did not economize on film.

Honorable Mention
The Human Environment
Don Gawronski

The colors of this setting impressed free-lance photographer Don Gawronski of Milwaukee, Wisconsin. The picture was taken on a cold winter's morning in 1976, on the city's south side where Gawronski grew up.


STOREFOR.
RENT.

West Indian Carnival in Brooklyn

by Donald R. Hill and Robert Abramson

James Joern

On Labor Day, West Indians in Brooklyn celebrate Carnival by parading in costumes. Some masqueraders, costumed to portray a theme, form groups called mas bands. At left is one of the principal costumes from "Exotics of Africa," a 1978 mas band. Steel bands and singers, above, often accompany mas bands in the Carnival parade.

es Joern

You could be from Saint Cleo or Jun Jun
In New York all that done
They haven't know who is who
New York equalize you
Bajan, Grenadian, Jamaican, tut mun [everybody]
Drinking they rum
Beating they bottle and spoon
Nobody could watch me and honestly say
They don't like to be in Brooklyn on Labor Day.

The Mighty Sparrow, "Mas in Brooklyn," Recording Artists Productions

On Labor Day, huge numbers of West Indians will gather on Eastern Parkway in New York City's borough of Brooklyn to celebrate Carnival. The informal line of steel bands, costumed masqueraders, and spectators will play, dance, eat, and carouse over the spacious parkway's ten traffic lanes, four sidewalks, and two grassy verges. The forceful rhythms of steel bands will compel marchers and spectators to "jump up," to dance "road march" steps individually or in lines. Amplified recorded disco, Jamaican reggae, Bajan (Barbadian) spouge, Haitian merengue, and Trinidadian soca and calypso will blare from buildings. All along the parkway there will be vendors of Trinidadian roti (East Indian curried chicken wrapped in a soft, flat bread), Jamaican beef patties, shark steak, and other island dishes. Malt liquor—very popular in the West Indies—will emerge from ice buckets; so much alcohol is consumed at Carnival that New York City police do not enforce the laws against public intoxication.

There will be individual costumes: some traditional; others social commentaries or burlesques. (Last year, there was a "baby" in a carriage nursing a bottle of rum, and a sorceress out of *The Wiz* trailing a train sporting a stuffed crocodile.) There will also be scores of mas (masquerade) bands, with live or recorded musical accompaniment. Each mas band consists of a king, a queen, and several other important figures—all in elaborate individual costumes—and any number of lesser male and female attendants in uniform costumes, depending on the band's theme, which may be drawn from history or current headlines, mythology or nature, folklore or popular culture. Huge ornamental floats, such as last year's pirate ship surrounded by buccaneers and dancing girls in grass skirts, will be rolled from side streets to the parkway

The parade will begin in the West Indian neighborhoods of south-central Brooklyn, and proceed roughly two miles northwest to Grand Army Plaza. There the larger bands will dissolve into smaller sections, which will keep on merry-making as long as Carnival lasts. At 11:00 P.M., Eastern Parkway will reopen to traffic, but groups of masqueraders, following any band that happens by, will continue their revelry en route to their homes nearby.

One of the largest folk festivals in the United States, Brooklyn Carnival is also among the world's premier pan-Caribbean celebrations. It may have begun as a substitute for similar celebrations in the home islands, but the West Indian population of New York, which surged in the mid-1960s because of liberalized United States immigration policies, considers the festival its own. In the West Indian cultural archipelago, Brooklyn is the major island, with a larger mixed West Indian population than any Caribbean country. More than half a million West Indians live in Brooklyn; about 30 percent, a plurality, are Jamaicans. The remaining 70 percent includes Trinidadians—whose Carnival back home serves as a model for Brooklyn Carnival—Virgin Islanders, Haitians, Barbadians, and a miscellany of other islanders.

Many West Indians belong to social clubs, benevolent associations, and friendly societies restricted to immigrants from their particular Caribbean country. But almost all the islands celebrate a community festival at Christmas, Mardi Gras, or Emancipation Day (August 1), which falls close to Labor Day. And so, on Labor Day in Brooklyn, allegiances to specific islands subtly shift to a new feeling of West Indian solidarity:

> Even though we tired and homesick
> Even though we want to roam
> Just give me my calypso music
> Brooklyn is my home.
>
> The Mighty Sparrow, "Mas in Brooklyn," Recording Artists Productions

Brooklyn Carnival's historical roots date back some three hundred years, to the West Indian festivals of French and British planters and their slaves. French colonists brought a Latin Carnival that preceded Lent and originated partly in Europe's pagan past. The high point of colonial

For several months before Labor Day, mas band designers rent Brooklyn storefronts, where relatives and friends help make costumes. Last year, one designer used American Indian costumes, below, an omnipresent theme at Carnival celebrations from New Orleans to Rio. Metalworkers and carpenters, right, work on a chariot, part of a historical theme. On the walls hang sketches of the designer's ideas, from which paraders can order costumes.

James Joern

British festivities was Christmastime serenading and mumming. One kind of masquerade that has been transplanted to Brooklyn in diluted form, without traditional mumming, is John Canoe (*see* "Slaves' Holiday," by Robert Dirks, *Natural History*, December 1975). This Jamaican mumming included scenes from Shakespeare's *Richard III* performed to fife and drum and slaves in whiteface dressed in British regimental uniforms.

In urban Trinidad of the 1890s, Christmas serenading began to show the influence of military musters that whites and free "coloreds" were obliged to attend. During serenading, ex-slaves began to copy and parody the drills. Military costumes are still seen in some traditional masquerades, even though younger participants usually do not know whom they are mimicking.

Slaves' celebrations at Christmas and other times of year combined entertainment, religion, and periodically, rebellion. In 1798, a few years after a slave revolt was bloodily crushed, one Grenadian planter wrote:

> At different times when the Runaway Slaves were numerous and troublesome they were in the habit of coming down from the Woods to mingle in the dance on Estates where the drum was permitted, and at such meetings concerted measures with the negroes on the Estate for plundering their master's property
>
> But the advocates of this dangerous custom generally permit it under the cloak of good nature
>
> *St George's Chronicle and Grenada Gazette*, November 13, 1798

The planter probably is referring to an early version of the Big Drum Dance, which planters once sponsored for their own and their slaves' amusement. An important part of the Big Drum Dance was kalinda, a ritual stick fight in which slaves—and after emancipation in 1833, ex-slaves—often representing different neighborhoods or villages, were pitted against each other. Kalinda used to be part of Canboulay, a defunct festival, whose name comes from Trinidad where slaves from many plantations used to be called together to put out cane fires—*cannes brûlées*.

After emancipation, ex-slaves began to mockingly reenact these gatherings every Emancipation Day (August 1) at Canboulay. Later, Canboulay was shifted to the day

James Joern

before Carnival, and it was the center of Trinidad's Carnival until the Canboulay riots of the 1880s. Suppressed by the British, the festival continued in the slums, embodying rebellion against colonial and modern metropolitan society and preserving elements of African folk culture.

While early forms of Carnival were for colonial planters only, Canboulay fetes after emancipation were dominated by former slaves, the lower classes. Carnival became a fete for the general public in the 1900s, but it did not become an official national celebration until Trinidad achieved full independence from Britain in 1962 and Creoles rapidly rose to political power.

In Trinidad, Carnival activities begin on Dimanche Gras, the Sunday before Lent. Carnival itself starts the following Monday, Jouvay Morning (from the French *jour ouvert*), a time for some masquerading and spontaneous dancing in the streets. Parades and band and costume competitions begin later that day and continue on Shrove Tuesday. Commercialism arrived in the nineteenth century in the form of calypso tents where entrepreneurs sponsored pre-Carnival shows. Increased commercialization came with the advent of twentieth-century tourism, the emergence of a Creole middle class, which organized competitions for mas band characters and calypsonians, and the development of large mas bands organized around themes.

In New York, several weeks before Carnival, commercial dance and band concerts of humorous calypso and rebellious reggae—which often expresses the "back to Africa" philosophy of the Jamaica-based Rastafarian cult—take place in all boroughs except Staten Island, which has no West Indian community. Some are elimination contests—preliminaries to competitions at the Brooklyn Museum, which the West Indian-American Carnival Association sponsors on the Friday, Saturday, and Sunday evenings preceding Labor Day, following the Trinidadian custom of holding concerts in the capital city, Port-of-Spain. Many West Indians from the home islands or from other east coast cities spend their vacation at Carnival, coming to Brooklyn to renew old acquaintances and settle personal affairs. In turn, many Brooklynites return to Trinidad Carnival, or travel to fetes in Boston, Toronto, Montreal, Washington, and London.

In Trinidad, steel-band members used to be young toughs; in Brooklyn, they are more likely to have a sponsor and to include women and musicians from different social classes. At left, the Sonatas Steel Orchestra, underwritten by an airline, plays at Carnival and church events. Metalworkers, below, make iron frames on which a steel band's drums can be rolled through Brooklyn's streets on Labor Day.

The three most obvious components of Brooklyn Carnival—calypso music, steel bands, and mas bands—are traditions belonging to older fetes in the islands. Part of a long tradition of topical Caribbean song, English-lyric calypso was first heard in Trinidad in the 1890s. Trinidadian legend talks about Gros Jean, Soso, and Papa Cochon, early masters of calypso, who modeled themselves after the African *griot*, or praise singer, and the European court minstrel.

Lionel ("Lanky") Belasco, a famous Trinidadian composer, musician, and orchestra leader, first recorded calypso during World War I, and introduced it into the United States about 1914, when the first wave of West Indian immigrants arrived in New York in search of work. The calypso of Belasco, and other musicians who followed him to New York in the 1920s, was topical music, recorded in New York—and occasionally in Trinidad—for a mainly Trinidadian audience. It usually concerned events at home, but sometimes considered immigrants' difficulties.

> When I first landed in the U.S.A.
> Listen how I got lost on the subway

Rufus Gorin, below, the first mas band leader to march his bands in Brooklyn for Carnival, displays an award (on which his name is misspelled) from the present Carnival's umbrella organization. At right, the Big Drum Nation Dance Company practices for Carnival in a Brooklyn basement. In Carriacou, in the Grenadines, the Big Drum Dance, which probably originated among slaves, is still part of some religious ceremonies.
James Joern

I had a date with a chick and I went to Brooklyn,
But I couldn't find my way back the following morning.
I had money yet I had to roam,
And still I couldn't get a cab to drop me back home.

I met a cop and told him I'm a stranger,
Lord Invader, a calypso singer.
I live in Harlem, I came yesterday,
Now I want to go home and I can't find my way.
He told me walk back three blocks and he further explain,
Go to the subway and take the uptown train.
I got confused, I was in a heat,
I couldn't find my way to 125th Street.

Lord Invader, "Yankee Subway" © 1955 Folkways Records and Service Corp

Today, at Brooklyn Carnival most "road marches" and calypsos are entirely new or reformulated, although some tunes are very old. Carnival-goers dance to calypso from steel bands with as many as thirty separate "pans," or percussion instruments.

Steel bands superseded earlier percussion bands in Trinidad shortly before World War II. During the war, most Carnival participation halted; at the same time United States naval bases and storage dumps on the island were discarding large quantities of fifty-five gallon metal drums. Bright, young, unemployed Trinidadians created a new instrument from the drums. Instead of playing one note by hitting a stick against the side or top of a drum, they tuned it so that they could play more than an octave.

On V-J (Victory in Japan) Day, 1945, this new instrument, the solo pan, came out into the streets of Port-of-Spain, in a new Carnival-like celebration that set the tone for the following decades:

V-J was a holiday
Black and white start to breakaway
Everybody join in the bacchanal
Getting ready for the Carnival.

Lord Invader, "Mary Ann" © 1955 Folkways Records and Service Corp.

Steel bands initially flourished among the urban poor in Port-of-Spain's barrack yards—back alleys and courts behind middle-class housing. With the advent of the steel band, mas bands grew larger and more elaborate, sometimes numbering more than a thousand participants. Today in Trinidad, and wherever Trinidad-style Carnival is held,

there are competitions between instrumentalists; like the older practices of stick fighters, these contests reflect neighborhood rivalries. Confrontations between rival bands have led to Carnival rioting in the islands and elsewhere.

Trinidad-style Carnival usually includes ole mas, literally old masquerade, a form of social commentary that is really visual calypso. A participant uses old clothes or cast-offs to make a costume with a message—usually humorous but sometimes biting or shocking. Honed by the strains that colonialism imposed on West Indians, ole mas often makes its point through reversals of role or power: a young middle-class woman may dress as a prostitute, a group of unemployed men may portray a prison gang. In Brooklyn two years ago, one ghastly figure depicted Son of Sam, a recently apprehended murderer. A middle-class Brooklynite disguised as a prostitute is acting not unlike the late eighteenth-century colonial island gentry, who masqueraded as slaves at balls. Jobless, working class men take delight in playacting as manipulators of society—people at the top of the heap or criminals who have broken all the rules.

Even as ole mas points up social divisions—class, status, and ethnicity—Carnival blurs and suspends them for the duration of the festivities, effectively working as a safety valve. For some participants, Carnival is a bacchanal, a time for sexual license; for others it is a time to express and enjoy a feeling of egalitarian communitas, fellowship.

> When you talk about bacchanal
> See Trinidad Carnival
> Good Lord! The biggest bacchanal
> Visit Trinidad Carnival
> All you gotta do when the music play
> Take your man and break away
> Regardless of color, creed, or race
> Jump up and shake your waist

The Mighty Sparrow [illegible] All rights reserved

Some Carnival masquerade traditions date back centuries to African and European sources, and have rich hidden meanings. On the other hand, some Carnival costumes and musical themes are only as profound and lasting as contemporary urban fashions. At Brooklyn Carnival, musical and masquerade performances are undergoing change, also evident to a lesser degree at Caribbean carnivals. There

On Dimanche Gras, the day before Labor Day, the West Indian-American Day Carnival Association holds a variety of contests. Near right: Beauty queens, sponsored by expatriates from certain Caribbean islands, spend long, unlovely hours awaiting judging. Far right: a dancer representing a Sioux Indian competes for a cash prize for best costume. Below: Steel band drums line up on their mobile racks for a battle of bands.

James Joern

James Joern

James Joern

Donald R. Hill

Left: Last year, two members of a "Star Wars" mas band danced disco style in the Carnival parade. Above: During the parade, one woman sold food cooked on the spot. Other vendors brought snacks cooked at home and sold them, wrapped in foil, from car trunks.

are fewer traditional skits and more contemporary pageants made up of floats, costumes, and dance. Before the days of steel bands, amplified music, and large organized mas bands, much of Carnival in the Caribbean consisted of performances by individuals or small groups. For instance, small groups of "Wild Indian" masqueraders would do a serpentine dance and sing in a language no one else could comprehend.

In Brooklyn, the traditional masquerade designs can still be distinguished, but the speeches and string band performances that often accompanied them have disappeared. Back home, each small performance in the little villages or the back alleys of larger towns meant something to the neighbors. Transplanted to Brooklyn, the great variety of dances seen in island performances has dwindled to two or three steps suitable for moving up Eastern Parkway in huge crowds. In New York City, the local villager has a new identity: he or she is not just an islander but a West Indian.

Carnival began in New York in the 1920s in Harlem's West Indian neighborhoods, where orchestra leaders and entrepreneurs began sponsoring masqueraders and reviews of calypso singing just before festivities began in the islands. In 1947, Jessie Wattle, a Trinidadian woman who wanted a summer festival in New York to remind her of Carnival before Lent back home, organized a parade through the streets of Harlem on Labor Day:

> Labor Day I felt happy
> Because I played Carnival in New York City
> Seventh Avenue was jumpin'
> Everybody was shakin'
> From 110th to 142nd
> We had bands of all description . . .
> This is the first time New York ever had
> Carnival on the streets like Trinidad.

Lord Invader "Labor Day" © 1955 Folkways Records and Service Corp

Harlem Carnival lasted until 1964, when a small riot disrupted the parade. The following year, the police refused to grant a permit. Meanwhile, a second wave of West Indian immigrants began arriving in New York. Many settled in Brooklyn, where in the mid-1960s, mas band leader Rufus Gorin, who had marched with Jessie Wattle in 1947, secured a permit to bring Carnival mas bands out on the narrow residential streets. Although Gorin still brings out his band and rides on its float, Brooklyn is no longer his Carnival.

In 1969, Carlos Lezama, a Trinidadian who works for the New York City Transit Authority, was able to secure a police permit for Carnival on Eastern Parkway, where it expanded to its present size and pan-Caribbean form, preserving mas bands, calypso, ole mas, steel bands, and the idea of kalinda in the form of band contests. Lezama is now president of the Carnival Association; like its other officials, he is unsalaried. The Association deals with the city government and police, smooths fractious islanders into a semblance of cooperation, and raises substantial sums from pre-Carnival performances and sponsors, but not enough to support mas and steel bands.

Of the Carnival principals only steel band leaders, pan tuners, and masquerade designers work year-round, albeit part-time, at these vocations, and most are not Association members. For these specialists, Carnival is an artistic expression and a demonstration of their ability to direct a large cast. Nevertheless, they often feel unrewarded, unrecognized.

Clement Samuels, pseudonym of a Trinidadian leader of a band that plays both soul and calypso, has participated in two Brooklyn Carnivals. A designer and trained musician, Samuels says, "the art of the masquerade and the friends that give me encouragement" are what make producing a mas band worthwhile. However, renting a storefront in Brooklyn—where Samuels, his relatives, and anyone else he can persuade to work without pay will make and sell costumes—is more expensive than setting up camp in a yard in Port-of-Spain. Samuels must also hire musicians to play on the parkway; this can cost him several hundred dollars. The costumes of the mas band's attendants, ordered and paid for by their wearers, usually cost less than $100 each. But each of the principal costumes may cost the designer $1,000. Samuels's sponsor, a local car rental agency, gives him only minimal support. He complains, "The Association is having the bread and butter and we're having the crumbs outside here."

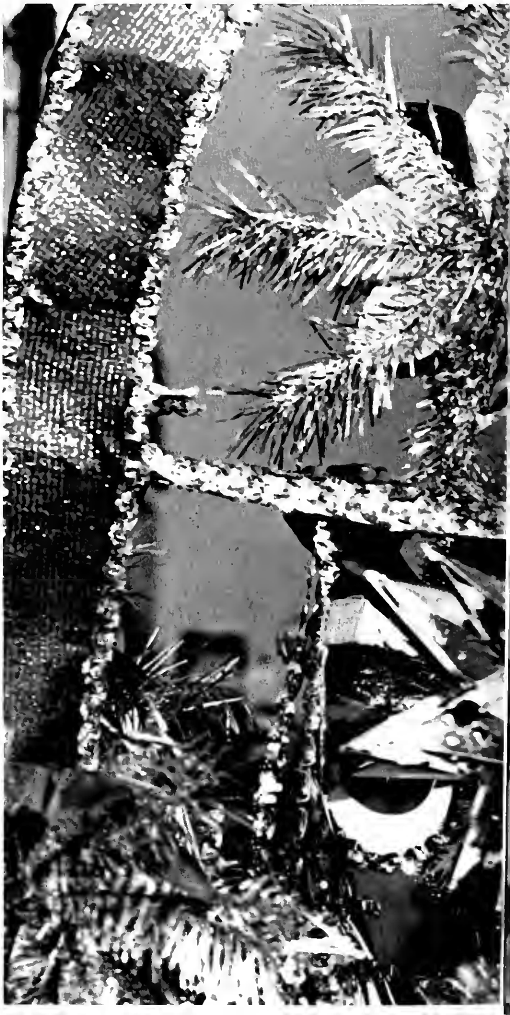
In July 1977, several weeks earlier than most designers, Samuels opened his Nostrand Avenue mas camp. As Carnival approached, customers came in to order costumes and friends dropped by. The radio was fixed on a Caribbean

Ronnie Ginniver

music station. Samuels, showing little concern for sleep or nourishment, put in long hours painting and pasting, cutting cardboard, covering costumes with tinsellike fabrics and glitter, and stringing dozens of masquerade hats up near the ceiling. One of the large characters was a Minstrel Man; the themes of the attendants' costumes were the Showgirl and the Hustler. Samuels thought sexy designs would draw women buyers.

But fewer members joined the mas band than he had expected, and fewer bands marched on the Parkway than the year before. His designer brother, whom he had expected to help, never arrived, and the musicians could not be hired. Nonetheless, Samuels participates in Carnival not only for monetary reward or professional success. Through the band, he seems to be trying to bring Trinidad closer: "Being here is not Trinidad, but I still feel at home with the people I have around me." Carnival remains "the spirit in my mind that turns me on to home. Keeping my country together, this is really what it comes out to here."

Samuels's difficulties illustrate the contradictions inherent in adapting a folk institution to an alien urban setting.



Above: In the "Exotics of Africa" mas band, two guards, wearing Rastafarian hair styles, marched with the queen. Celebrating carnival brings moments of strain. Right: a mas band designer's daughter staggers under the unwieldy frame that complements her headdress and costume.

James Joern

Although the ethos of Carnival is play and enjoyment, the preparations entail much hard work and expenditures that defy economic logic. In Brooklyn, steel bands can expect to break even, but for most masquerade designers the financial returns are disappointing year after year.

Although there were fewer masquerades in 1977, they are by no means disappearing. Rufus Gorin thinks "bringing out Carnival is bringing out the art; without the art there would be no Carnival." Every year the evanescent "art"—the costumes and floats that are discarded as quickly as the fete is ended—must be put together again, but people remember and anticipate Carnival, which may provide what patriotism, church affiliation, and cultural institutions might otherwise give.

On the other hand, Carnival, in Brooklyn and elsewhere, is not entirely unifying warmth; a ritual of the dispossessed, like the Big Drum Dance of Caribbean slaves, it helps maintain the status quo. The greater the inequalities in the society that is host to creole Carnival, the more spectacular the festival. As long as these inequalities are parodied in an orderly way through performances that are encouraged by the surrounding society, Carnival remains frivolous.

But when people suffer economic deprivations and no longer accept their low status in a polyethnic Western society, Carnival's mock battles and power reversals may become genuine revolt. Such was the case after emancipation when Canboulay, the Carnival of the ex-slaves, replaced the fancy dress ball Carnival of their former owners, and again in the 1880s, when riots marked the decline of Canboulay. After World War II, widespread unemployment in Trinidad led to steel band riots in the late 1940s and early 1950s. Racism may have been a factor behind the 1964 Harlem riot, which occurred during widespread disturbances over civil rights in the United States. Unemployment and racism in England sparked the Notting Hill riots during London Carnival in 1976.

Carnival, then, is an accurate gauge of strain in the host society. At present, Carnival in Brooklyn is a huge party where guests indulge themselves with food, liquor, music, and camaraderie. But, in the light of its history, Carnival's spectacle must be regarded as potential rebellion, the other face of communitas. □

False Start of the Human Parade

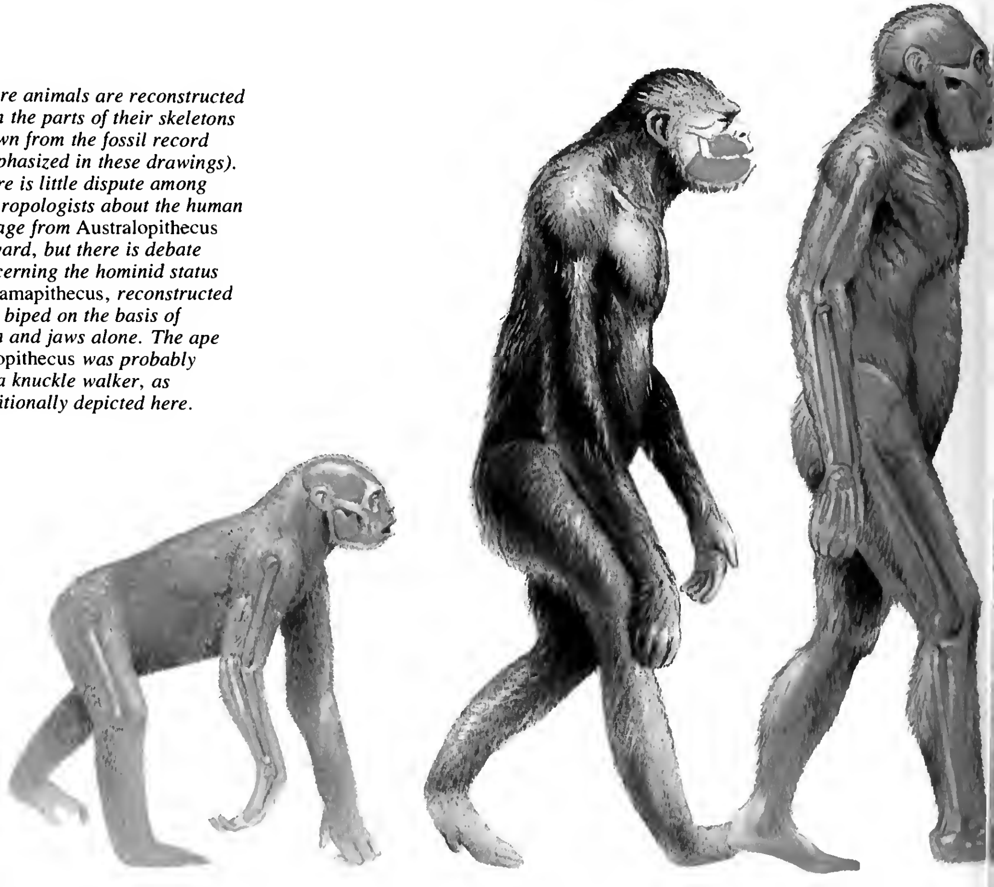
Once reconstructed as an upright ancestral human, Ramapithecus *must bend before the evidence of molecular anthropology*

by Adrienne L. Zihlman and Jerold M. Lowenstein

Books on human evolution often feature an artist's conception of our ancestry as being a kind of parade led by a contemporary man, with Neanderthal man, *Homo erectus*, *Australopithecus*, and others following in their proper places. Near the end of the line, but walking upright, is the creature called *Ramapithecus*, no doubt relieved not to be a mere ape like *Dryopithecus*, who trails on all fours. There is unequivocal evidence from pelvic, leg, and foot bones that all species of the genera *Homo* and *Australopithecus* were in fact bipedal. But how did *Ramapithecus*, a fossil "hominoid" reconstructed only from teeth and jaws—without a known pelvis, limb bones, or skull—sneak into this manward-marching procession?

Human nature abhors a vacuum, particularly a genealogical one. There have always been gaps in the fossil record of human evolution but never a shortage of speculative "missing links." So convinced were anthropologists of the early twentieth century that the ancestral human was a large-brained half-ape, that Piltdown man, a hoax consisting of a human skull and

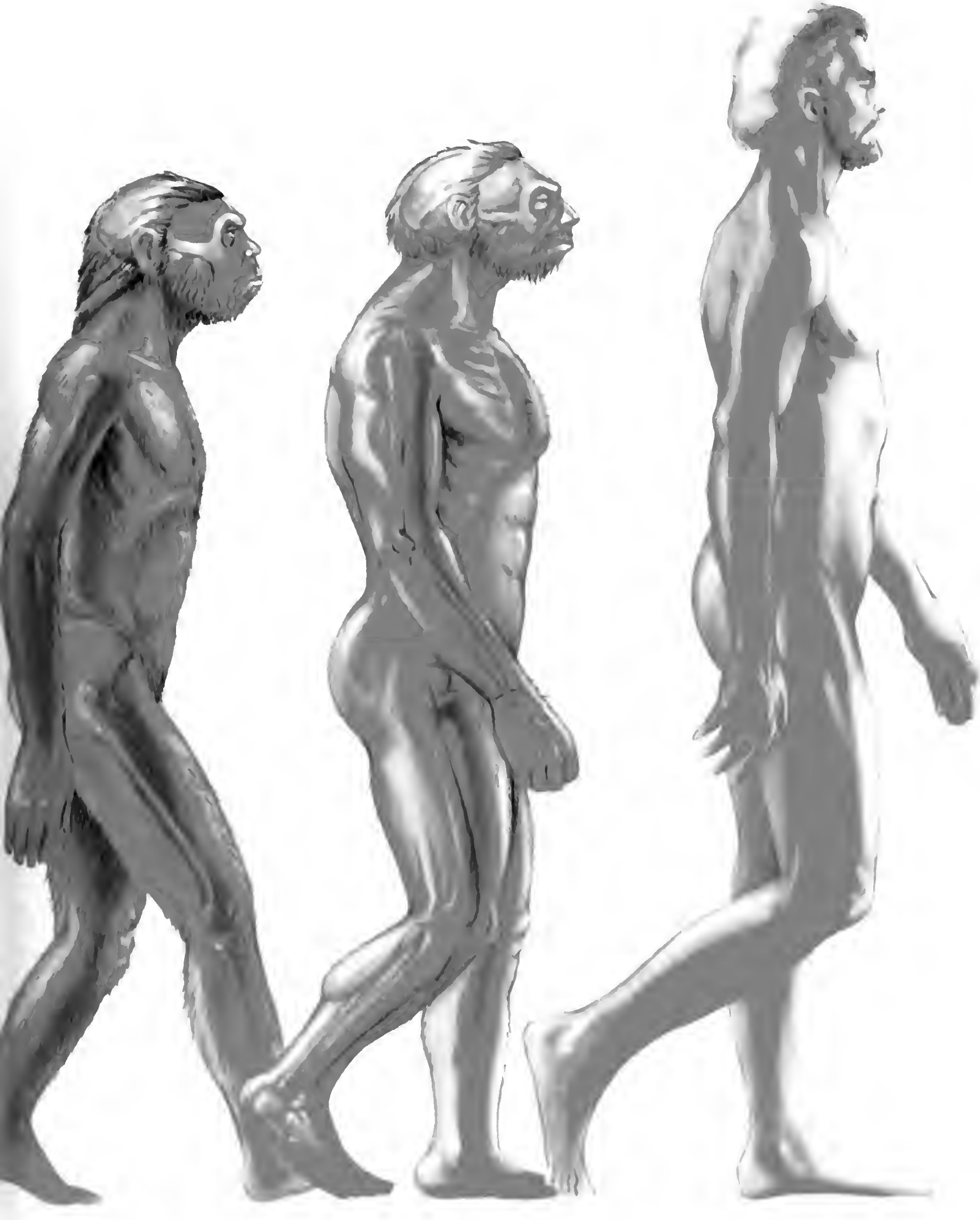
Entire animals are reconstructed from the parts of their skeletons known from the fossil record (emphasized in these drawings). There is little dispute among anthropologists about the human lineage from Australopithecus *forward, but there is debate concerning the hominid status of* Ramapithecus, *reconstructed as a biped on the basis of teeth and jaws alone. The ape* Dryopithecus *was probably not a knuckle walker, as traditionally depicted here.*



Dryopithecus ***Ramapithecus*** ***Australopithecus***

20 million years ago — 10 million — 1.5 milli

Illustrations by Douglas Cramer



Homo erectus — *Homo sapiens neanderthalensis* — *Homo sapiens sapiens*

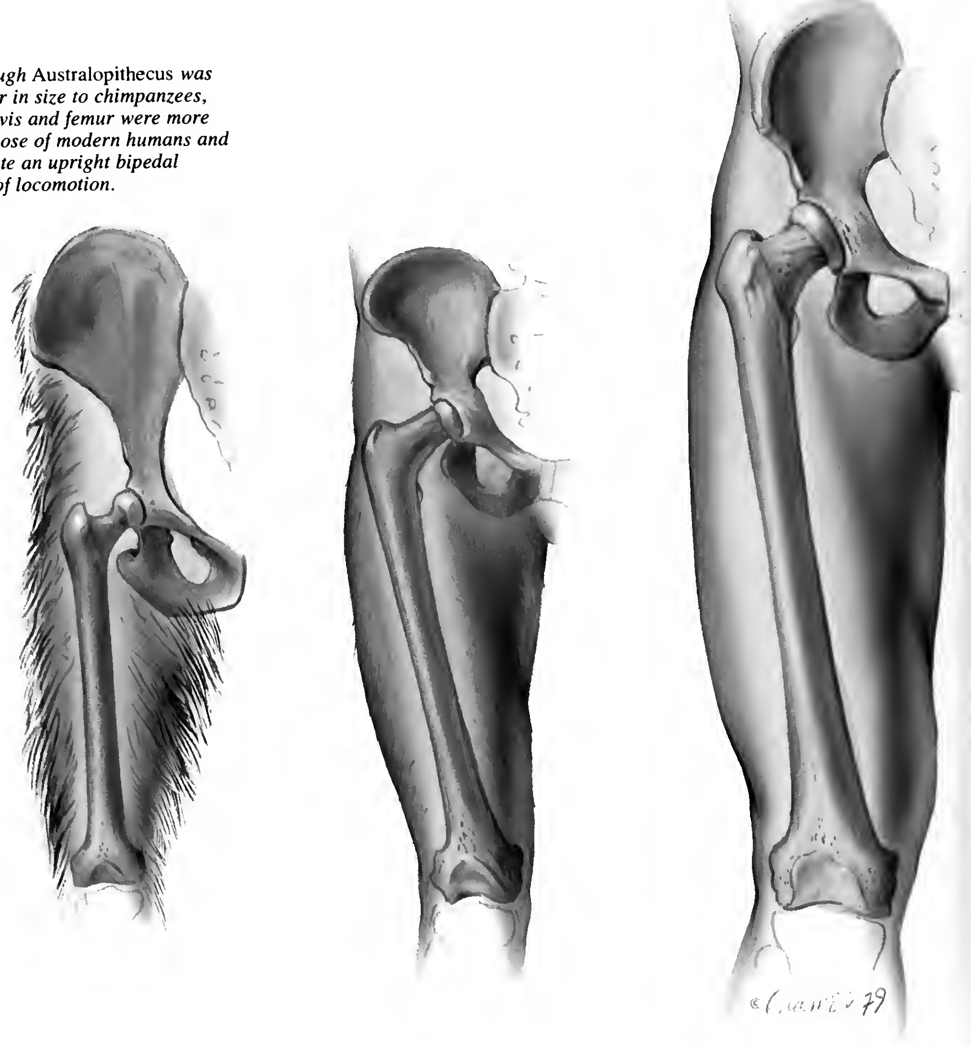
100,000 — present

an orangutan jaw with the teeth filed down, was not only accepted but embraced by all but a few skeptics for nearly forty years.

At about the same time that Piltdown man was being enshrined in textbooks, a real "missing link," recognized by Raymond Dart in South Africa in 1924, was almost universally rejected by the scientific establishment. Anthropologists expected a large-brained ancestor, but what Dart and Robert Broom, and later Louis and Mary Leakey, found was a small-brained ape-man, with undeniably bipedal pelvic and lower limb bones. But before *Australopithecus* could be accepted as root to humans, Piltdown had to be eradicated from the family tree. After fluorine chemistry and other evidence accomplished that, the increasing number of hominid finds from Africa could be given their rightful significance.

By 1960 a series of fossils had been discovered, going back in time from modern man, *Homo sapiens sapiens*, (to 30,000 years ago) and the subspecies *H. s. neanderthalensis* (70,000 years) through *H. erectus* (more than a million years ago) and *Australopithecus* (now as old as 3.5 million years). This of course left the question, what came before the australopithecines? Unfortunately, the fossil record for hominids (the human family) and pongids (the ape family) is almost totally blank between four and eight million years ago—an irresistible tabula

Although Australopithecus *was similar in size to chimpanzees, its pelvis and femur were more like those of modern humans and indicate an upright bipedal form of locomotion.*



Chimpanzee **_Australopithecus_** **Modern human**

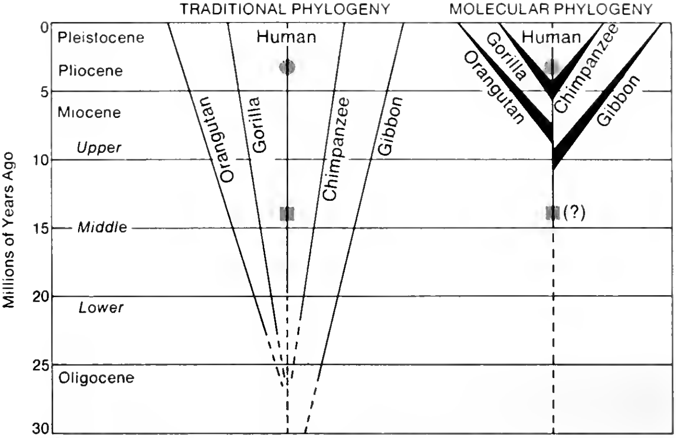
rasa on which to inscribe belief, preconception, and personal opinion.

For many contemporary anthropologists, the ancestor-nominee for this dark age is the Miocene primate *Ramapithecus*. In contrast to the bare upper Miocene-Pliocene cupboard, the middle to lower Miocene (15 to 25 million years ago) offers a rich fossil primate record of worldwide distribution, which includes several genera and species of extinct apes and a few monkeys; significant for this account are two groups of apes—*Dryopithecus* and *Ramapithecus*.

Jaws and teeth of *Dryopithecus* ("oak ape") were first found in France more than a hundred years ago, and before the end of the nineteenth century they had been recognized as possible remains of ape and human ancestors. Since that time, a large variety of dryopithecines have been unearthed in Asia and Africa, as well as Europe. They are, as Sherwood L. Washburn dubbed them, "dental apes"; their teeth resemble those of modern apes but their monkeylike limb bones suggest four-legged locomotion. Their shoulder, elbow, and wrist joints lack the specialized adaptation for hanging and swinging through trees (brachiation) that characterizes all modern apes—gibbons, orangutans, chimpanzees, and gorillas (this lack should suggest they were not knuckle walkers, although that is how they are commonly depicted). The pelvis, so critical for interpreting locomotion, remains unknown; not a single specimen has been uncovered.

The genus *Ramapithecus* was named by George E. Lewis in 1934 after the mythic Hindu prince Rama, hence "Rama's ape." The few teeth and jaw fragments found in India in 1932 suggested to Lewis the possibility that the genus might be hominid. Subsequent specimens have been found in East Africa, Pakistan, and Hungary. The only firm date, established by the radioactive potassium-argon method, is for Louis Leakey's find at Fort Ternan, Kenya—14 million years ago; faunal dating would make the Pakistani, Indian, and Hungarian fossils between 8 and 12 million years old. We thus have at least a 4-million-year gap between the youngest known ramapithecine and the oldest known australopithecine.

Most researchers regarded the creature as a type of *Dryopithecus* until 1961, when Elwyn Simons raised it to hominid status in his article "The Phyletic Position of *Ramapithecus*." He stated that it "can be defended as being within or near the population ancestral to Pleistocene and subsequent hominids." Louis Leakey drew similar conclusions from the Fort Ternan specimen. In 1964, with no new evidence, Simons proclaimed that *Ramapithecus* was "the earliest known human ancestor," a claim that he and others have vigorously defended since then.



Australopithecus (3.5 million years ago) *Ramapithecus* (14 million years ago)

The evidence for hominid status, as Lewis and later Simons saw it, was the supposed parabolic shape of the dental arcade (as reconstructed from jaw fragments), a characteristic of hominid jaws that contrasts with the parallel dental arcade in apes. The upper canines were said to be too small for an ape (although they are no smaller than those of the living pygmy chimpanzees). Enamel thickness and cusp patterns were also interpreted as being more hominid than apelike. In 1964 Simons concluded that "dental and facial characters are so close to *Australopithecus africanus* as to make difficult the drawing of generic distinctions between the two species on the basis of present material."

Now, fifteen years later, we have more teeth and some complete jaws, which prove to be V-shaped rather than parabolic, but never mind—Simons proves in a 1977 *Scientific American* article that the V-shape is more hominid than apelike. There are still no skulls, no pelvic or limb bones unequivocally associated with the teeth to show whether *Ramapithecus* had a brain like a hominid, swung through the trees like an ape, or walked upright like a human.

Almost two hundred years ago Cuvier boasted, "Give me a tooth and I'll reconstruct the animal," but paleontologists have learned the hard way that limbs of an extinct species cannot always be presumed from the teeth alone. A famous example of the unexpected is the chalicothere, an animal with teeth and skull like a horse's, but with claws instead of hoofs. For a long time, its teeth and claws were thought to be from two different species, until the discovery of an entire skeleton proved they belonged together.

The pelvis is probably the most diagnostic bone of the human line. (*Australopithecus*, although its brain was not much larger than an ape's, had a pelvis more human than apelike.) Yet an entire *Ramapithecus*, walking upright, has been "reconstructed" from only jaws and teeth. In 1961 an ancestral human was badly wanted. The prince's ape latched onto the position by his teeth and has been hanging on ever since, his legitimacy sanctified by millions of textbooks and Time-Life volumes on human evolution

There are no convincing new pretenders to the ancestral throne, but something has happened in the intervening years to make *Ramapithecus*'s claim more dubious. A new field called molecular anthropology has come of age, and the findings of researchers, especially Vincent Sarich and Allan Wilson at the University of California, Berkeley, make it extremely improbable that there were any ancestral humans, in the strict sense, longer than six million years ago

Molecular anthropologists study the similarities and differences in the pro

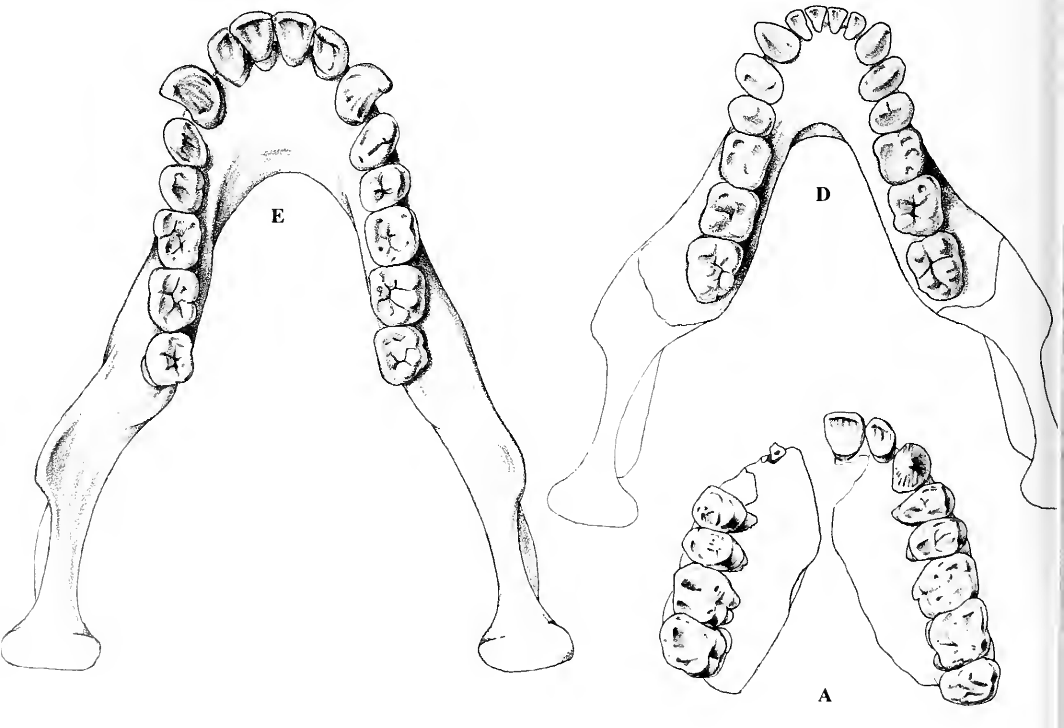
teins of living species and deduce how long ago they diverged from a common ancestor. Proteins are made up of various combinations of the basic twenty amino acids, arranged in definite sequences. A given protein may include hundreds or thousands of amino acids. The proteins of closely related species, such as horse and donkey or dog and fox, are nearly identical, whereas species that diverged more than a hundred million years ago, such as shrew and opossum, have many sequence differences. These differences can be measured precisely, and their number is approximately proportional to the divergence time. Such "molecular clocks" are particularly valuable for evolutionary study because results can be, and have been, replicated in different laboratories, whereas the analysis of fossil bones and teeth is much more subjective.

The most startling discovery of molecular anthropology for those trained in the older tradition is the close, even intimate, relationship of man and the African apes. Comparison of blood proteins (albumins, transferrins, hemoglobins) and the genetic material itself, DNA, has shown about 99 percent sequence similarity for humans, chimpanzees, and gorillas. This makes them as similar as such closely related species as horse and zebra or grizzly bear and polar bear. These studies have been extended to more than forty different proteins, tested independently by dozens of researchers. The results are remarkably consistent and support the conclusion that humans, chimpanzees, and gorillas diverged from a common ancestor between four and six million years ago.

That common ancestor was almost certainly some kind of ape. Even allowing for statistical error, one should not expect to find a fossil human that existed eight million years ago. Sarich in 1971 concluded that "one no longer has the option of considering a fossil specimen older than about eight million years as a hominid *no matter what it looks like*." This "overenthusiasm for a new technique" was ridiculed by Glenn Conroy and David Pilbeam in a 1975 review of the hominid status of *Ramapithecus*. Elwyn Simons has flatly stated that "the molecular clock does not keep good time."

To consider *Ramapithecus* a hominid, however, one would have to assume that primate proteins have evolved at half the rate of shark, fish, frog, snake, kangaroo, mouse, and elephant proteins. Although this constitutes a kind of "special creation" hypothesis, it is accepted by some of the strongest defenders of Darwinian evolution—so convinced are they that *Ramapithecus* is an early hominid. They have argued that proteins evolve more slowly in animals with longer generation times—a presumption refuted by the evidence that mouse and elephant proteins have evolved at the same rate, as have lemur and human proteins. This external check on the constancy of the molecular clock is further supported by internal evidence: numerous proteins with different rates of change (cytochrome *c*, albumin, transferrin, hemoglobin) indicate the same divergence times. That is like timing the same event with an hour hand, minute hand, and second hand, and finding out that the times come out the same. As Sarich has repeatedly pointed out, the statistical constancy of the molecular clock is not an assumption but an observation based on an enormous amount of data.

The change in living proteins with time and speciation is analogous to the radioactive decay of isotopes such as



carbon-14 and potassium-40. Both are statistical processes wherein long-term changes are predictably constant, even though short intervals may show wide, random fluctuations. Most anthropologists and paleontologists welcome radioactive dating as a scientific time scale, where previously there was much guesswork and confusion about the age of fossils. But these same scholars have almost universally, and sometimes emotionally, rejected the findings of molecular evolution, primarily because these challenge, indeed refute, the claim that *Ramapithecus* was the ancestral human.

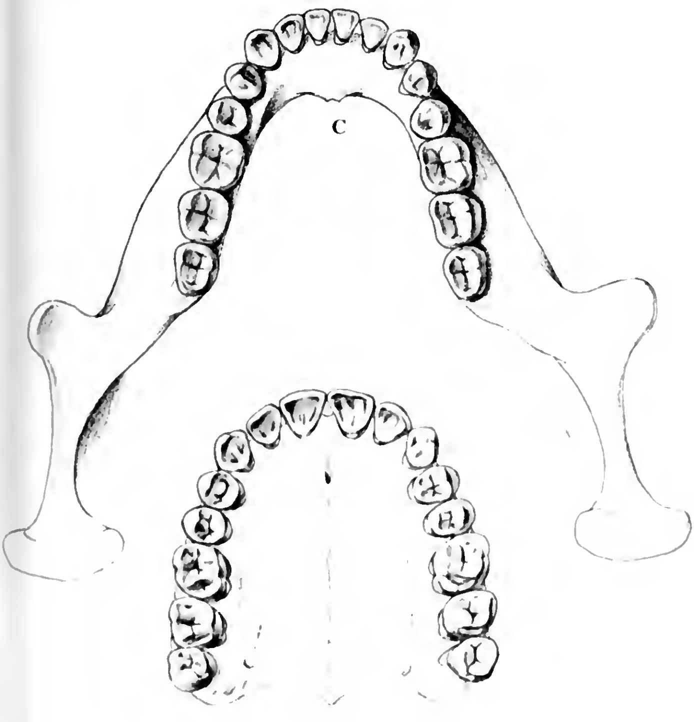
The molecular findings not only rule out middle Miocene hominids, they also spoil the popular anthropological game of looking for separate Miocene or Oligocene ancestors for all the modern apes. Over the years, many fossil apes have been nominated as the "ancestral gorilla" or "ancestral chimpanzee" or "ancestral gibbon," on the assumption that these genera, like the human ones, had been distinct for 15 to 30 million years. From their molecules, the Asian apes (orangutan and gibbon) split from our common ancestor about 10 million years ago. And, from the biochemical evidence, there was but one ancestor—not three different ones—for man and the African apes. No known fossil ape or human remains contradict this chronology.

It seems that the biochemical evidence is, directly or indirectly, having an influence on what people "see" in fossils. In a recent article David Pilbeam, long an advocate of the hominid status of *Ramapithecus*, recants his view, basing his conclusions on—guess what—the V-shaped character of the ramapithecine jaw! Without mentioning the biochemistry, Pilbeam states: "As I now realize, extinct hominoids were not particularly modern. They were not like either living apes or human beings, but instead were unique, distinct animal species. . . . Consequently, *Ramapithecus* is still important in the story, but it is not the star. . . . The first hominid was probably a species of *Australopithecus.*"

A just announced candidate for the ancestral hominid is *Australopithecus afarensis*, so named by Donald Johanson and Tim White in a recent issue of *Science*. Some of this material from East Africa has been known for more than four years and is very similar morphologically to fossils from Sterkfontein Cave in South Africa known for over thirty years: that is, the finds indicate small creatures, chimplike in body size and skull shape, but bipedal like humans. Johanson and White discuss the apelike features of the skull and teeth and—again, without mentioning the molecular evidence—state that this implies a relatively recent divergence of man from the African apes. One begins to detect a groundswell among anthropologists for reversing the molecular argument by claiming that the *fossil* finds now so strongly suggest a recent divergence that the despised biochemistry may turn out to be right after all.

What, finally, can we say about the position of *Ramapithecus* in primate evolution? One of several kinds of apes that lived during the Miocene, it may have fed in open country, developing jaws and teeth for chewing tough roots and fibers. Such an adaptation would have been parallel, not ancestral, to the one evolved millions of years later in *Australopithecus*. Or possibly, a ramapithecine was the common ancestor to both modern apes and humans, and not to humans alone. Without more parts of the animal, these are still matters for speculation. But whatever the conclusion, theories of ape and human evolution must be compatible with the fossil evidence, with comparative anatomy, and with established rates of protein evolution.

The case for *Ramapithecus* as an ancestral human has been weak from the start and has not strengthened with the passage of time. Now that the molecular data are in, the mythical prince's ape, who would be man, has faded until nothing is left but his smile. □



B

In the standard reconstruction of the Ramapithecus *upper jaw (A), made without benefit of a midline contact point, the contour was presented as parabolic, like that of* Homo sapiens *(B). However, when a complete* Ramapithecus *lower jaw was found, it proved to be V shaped (D), not parabolic, like a human jaw (C), or parallel, like a chimpanzee jaw (E).*

The Hummingbird and the Calorie

Sometimes it pays to fight for your nectar and sometimes it doesn't

by Paul W. Ewald
photographs by Robert A. Tyrrell

Summer brings dry heat to the hills of southern California, baking the moisture from the surface layers of soil. As the moisture vanishes in this chaparral community, so do most of the nectar-rich flowers so important to the survival and procreation of hummingbirds during winter and spring. During the summer months, only plants specially adapted for coping with the water shortage will bloom: scarlet monkey flowers cling to banks of receding rivulets and the drought-hardy tree tobacco blots up scanty pockets of underground moisture. But these flowers are insufficient to support large summer populations of hummingbirds—populations swollen with the year's crop of immatures, newly fledged from their nests.

Many hummingbirds abandon the chaparral as temperatures climb and supplies of nectar diminish. They migrate to higher elevations where wildflowers still bloom abundantly or to developed areas, where they can feed on cultivated flowers and at artificial feeders filled with sugar water.

Of the hummingbirds that remain in the chaparral many make local excursions to stands of California live oak and western sycamore that rise from canyon bottoms. Here hummingbirds can move from sunny to shady perches with little effort. Such easy access to a variety of microhabitats is especially important for the birds because their small size makes them particularly vulnerable to extreme temperatures.

Even in midsummer, early mornings are cool in the chaparral. Hummingbirds spend much of this time on sunny perches to reduce the high rate of heat loss caused by their small body size and high, constant body temperature. By reducing heat loss they can save valuable energy for other purposes. When insolation is strong and air temperature high, their body temperatures can rise quickly to lethal levels. So, as temperatures of sunny perches rise into the eighties, hummingbirds move to shady perches.

Chilling and overheating are not the only concerns of the hummingbirds. The limited supplies of nectar force them into keen competition for food. If flowers are sufficiently clustered and nectar rich, the rewards of evicting competing hummingbirds from these clusters may exceed the costs of defense, and certain hummingbirds will establish themselves as the "owners" of floral patches. Hummingbirds without such territories harvest nectar by intruding on owned floral patches or by feeding on flowers too sparsely distributed to be incorporated into a territory.

One denizen of the chaparral, the Anna's hummingbird (*Calypte anna*), defends its territory by both ritualized communication and aerial attacks. The rituals are vocal or visual and fall into two major categories: announcement and threat. When food in a territory is not in immediate danger of being stolen, territorial males often become engrossed in "announcement song"—a recurring sequence of raspy triplets, a drawn-out creak, and two staccato chirps. The song broadcasts two messages: "I am present on this piece of property" and "I own it." While singing, the owner shifts its head from side to side, visually reinforcing its song with iridescent flashes of crimson.

The announcement song seems to function as a deterrent. After noticing the presence of an owner, intruders frequently avoid the territory without even attempting to steal food. Apparently, their foraging success is greater if they move on to undefended food sources or to territories whose owners are temporarily absent.

An intrusion on the territory, or the close approach of a would-be intruder, elicits a "chatter" from the owner. Like the buzz of a rattlesnake, the sound and meaning of the call threaten an attack.

A third line of defense—the gorget

The summer heat of the chaparral drives a male Anna's hummingbird to a California live oak growing in a canyon. When the temperature goes above 80°F, the small birds need the shade of trees to survive.

display—acts as a close-range threat. The resident bird fluffs up its feathers, creating an illusion of larger size, releases a barely audible, high-pitched peep, and vigorously throws its head from side to side. The neonlike flashes from the gorget are further accentuated by erection of the peripheral gorget feathers.

If these ritualized methods of defense fail to deter an invader, an aerial attack will usually ensue. If the intruder sees this approaching assault, it nearly always flees from the territory. However, if it does not see an attacking owner, actual contact may take place. When territorial ownership is at stake, such encounters will occasionally escalate into fierce combat: the contestants face off in midair, lunging with their bills and pummeling with their wings. Sometimes the pair may even fall to the ground during the tussle. I have never observed serious injury from such conflicts, but when I once mounted a deceased hummingbird in a perched position and placed it on a territory, the owner of the territory flew over for a closer look and then stabbed at the eyes of the mount with its bill.

When nectar is at stake, territorial conflicts are not restricted to competitors of the same species. Aerial attacks occur frequently between different species of hummingbirds and, occasionally, between entirely different phyla of animals. I once observed a territorial Anna's hummingbird unable to feed because it was repeatedly beaten back from its feeder by a paper wasp that was using it. However, hummingbirds are not always destined to defeat in such encounters; they occasionally attack and drive away bees that attempt to feed at their flowers.

Do hummingbirds use their repertoire of fighting skills selectively depending on the caloric gains and losses associated with each type of behavior? This question was investigated by reducing the amount of food in hummingbird territories on successive days. The technique was to provide a territory with a single food source—a specially designed feeder containing a specific concentration of sugar water. The amount of food available to the owner was reduced by adjusting a valve near the tip of the feeder. The results of this experiment showed that Anna's hummingbirds alter their defense tactics when the amount of food on the territory is reduced. Owners of rich territories streak from their perches like antimissile missiles to intercept invading hummingbirds. In such an encounter, the owner will frequently pursue a fleeing invader far beyond the territorial boundary.

In contrast, when territories are poor, owners shift from actual attacks to ritualized defense, using both chatter and gorget displays to a greater extent. Even the characteristics of actual attacks change; owners fly more slowly and attacks are of shorter duration, usually not continuing beyond the territorial boundary.

These alterations of defense tactics seem to be strategic modifications that increase an owner's prospects for survival. Actual attacks are more effective than rituals for expelling invaders, but they are more expensive energetically. Attacks are also probably associated with greater risks of injury. When territories are rich these costs are apparently offset by more exclusive control of food.

In poor territories, however, residents can keep the food sources well drained by frequent visits. If an intruder feeds, not only will it obtain little food but it should also be less inclined to return to that poor foraging spot. Under these conditions the best strategy appears to be ritualized defense against most intruders, and short chases when resources are in immediate peril—vigorous attacks being prohibitively costly for the meager benefits derived.

One purpose of this experiment was to discover the point at which a territory becomes so poor that an owner abandons defense completely. As the availability of food was reduced, owners left their territories more frequently and for greater lengths of time. Presumably, these departures were "grocery runs" through which owners fend off starvation by feeding on undefended food sources or by stealing drinks from other territories. Surprisingly, territories were defended even when the feeders provided no food.

This result suggests that territorial hummingbirds integrate both past and present information about territory quality when deciding whether to defend an area. This seems logical because energy obtained from a patch of flowers can fluctuate substantially even within a period of hours—some knowledge of how rich an area has been in the past could be helpful in deciding whether the area will be worth reserving for the future.

If this explanation is correct, areas that have always contained little or no food should not be defended. To test this hypothesis, feeders were placed on areas that had not previously contained any nectar-type food. As predicted, feeders of very low quality were not defended. Defense occurred only when the daily allowance of food from the feeders was more than about one-tenth of an owner's daily requirement.

In combination, these experiments show that hummingbirds are more likely to defend an extremely poor territory if it had previously been of high quality. But how much of the past influences the decision to defend a territory? A resident might need many days to determine how the overall productivity of a flower patch is changing. To gain insight into a territory owner's ability to incorporate information from the past, I conducted another experiment. Individuals were allowed to establish territories at feeders that provided unrestricted amounts of food for periods of one day to over a month. These feeders were then replaced with sham feeders that provided only water. When hummingbirds were allowed to use the rich feeders for one day, they abandoned defense of the sham feeders after approximately one hour. However, they defended shams for as long as two days when their prior ownership of rich feeders was increased to two weeks. Increasing their exposure to rich feeders beyond two weeks did not increase the subsequent defense of sham feeders. Thus, owners incorporate at least two weeks of past information in their decision to defend or abandon a territory. The biological mechanism could be one of evaluation and memory or simply habit; determining which one remains to be solved.

These findings show how hummingbirds alter their defensive behavior as resources vary on a day-to-day time scale. But the dynamics of their territorial behavior are even more complex; minute-to-minute adjustments also occur. Owners are more likely to feed immediately before departing from the territory than at other times. These feedings reduce nectar loss to competi-

The feathering of a female Anna's hummingbird may serve as an antipredator device, especially during the nesting period. Brighter coloration would draw attention to her and the vulnerable nestlings.

During dry periods when flowers are scarce in the chaparral, Anna's hummingbirds will imbibe nectar from such poor nectar producers as Dudleya *and other drought-resistant species.*

tors that intrude on the territory during the owners' absence.

In addition, intruders encountered within the first few minutes after the owner has fed are less likely to be chased than those encountered later. By reducing the intensity of defense shortly after feeding, owners save on energetic expenditures and reduce their risk of sustaining injury from combat. Furthermore, little food is lost to intruders—even if an intruder feeds, it harvests little from the recently drained food sources.

These short-term modifications of territorial behavior are tinged with deception—they mimic the defense of poor-quality territories. An intruder encountering low food abundance on a territory and a passive (or absent) owner would not know whether this situation resulted from low productivity or a recent feeding by the owner. If the intruder knew that a recent foraging bout was the cause, its assessment of territory quality should be higher, and it should be more likely to return. The result for the owner would be increased costs of defense or losses of food.

These discoveries show that the repertoire of territorial behavior exhibited by the Anna's hummingbird is not merely a conglomerate of redundant messages. Rather, like a seasoned boxer, it uses its fighting skills selectively. "Knockout punches" are thrown when the expected gains outweigh the cost of escalation. But at other times, energy is conserved while the opponent wears itself down in its attempts to break through the owner's defenses. For hummingbirds, the reward is the elusive calorie, a key requisite for their survival.

Hummingbirds are brightly colored, and coloration is often used as a means of communication in animal societies. After a century of scientific debate, the exact information that is communicated by patterns of coloration remains enigmatic. Several social functions have been proposed: to attract sexual partners, to allow individuals to

distinguish their species from other species, to aid in defense of resources, and to signal social status. The exaggerated gorget display used by Anna's hummingbirds is a clue that in this species bright color communicates information important for defense of resources.

Understanding the significance of such chromatic communication is especially challenging in hummingbird societies because many individuals do not possess a complete gorget. Anna's hummingbirds offer a typical example. When immature males fledge from the nest, they possess pallid throats and foreheads, entirely devoid of red feathers. These iridescent feathers then appear sporadically until approximately seven months after fledging. At this time a dramatic alteration in the gorget region marks the entrance into adulthood: all feathers on the throat and forehead are replaced, transforming the patchy iridescence of immatures into the immaculate gorget of the adult.

If bright coloration aids in territorial defense, bright individuals should require less effort than dull individuals to defend a territory. This idea was tested on Anna's and black-chinned hummingbirds by simultaneously observing owners of adjacent territories. Each of these "next-door neighbors" were provided with identical feeders, but the owners differed in the amount of bright feathering in their gorgets.

Although artificial, such controlled techniques are important for field experiments because territorial behavior is strongly affected by the distribution and abundance of food, structure of vegetation, and time of day. Without this artificial control an experimenter would not know whether observed differences in territorial behavior were caused by differences between the owners or by differences in environmental variables.

In both species, bright owners spent less time and energy in aerial defense than dull owners, adults spent less than immatures, and bright immatures spent less than dull immatures. This result occurs because chases by bright owners are shorter and less frequent than those of dull owners. Since intruders frequently avoid a territory upon noticing the presence of an owner, bright coloration could decrease both the frequency and duration of chases simply by making owners more visible. Of course, the positive correlation between age and coloration yields an alternative explanation: the decreased defense expenditures could be caused entirely by increased experience.

If bright coloration is an asset for defending resources, another key question arises concerning patterns of coloration in hummingbird societies. Why do females and immature males usually possess little or no bright feathering on their throats and foreheads? There must be some compensating advantages to being dull.

One possibility is that dull individuals suffer less pressure from predators. Nesting females seem especially vulnerable; visual broadcasts from the mother during incubation and care of young could increase the risk of predation not only on the mother but also on the offspring. In most species of hummingbirds, these risks would influence only female coloration because males do not aid in incubation or raising of young.

Not surprisingly, females typically possess only a small patch of iridescent red feathers on their throats and none on their foreheads. In accordance with their less extensive coloration, females are territorial far less often than males. Female territoriality often occurs during the breeding season, but is usually limited to short chases at floral patches near the nest.

Anecdotal accounts yield a rather bizarre list of occasional predators on nonnesting hummingbirds: leopard frogs, bass, road runners, kestrels, and merlins. If brighter individuals suffered higher predation, bright coloration could be especially disadvantageous for immature birds. Their inexperience could make them not only more susceptible to predators but also less able to establish and maintain a territory. In this case, increased susceptibility to predators could offset the meager advantages of brightness gained through aggressive control of resources. The major weakness of this argument, however, is that predation on nonnesting hummingbirds seems to be extremely rare.

Another possible advantage of dull coloration is greater success at stealing drinks from territory owners. Quantified observations support this idea. When owners are present, dull intruders gain energy at a greater rate than bright intruders. When owners are absent, there is no significant difference between the success of dull and bright intruders. Again, bright coloration may be causing these results by increasing the visibility of individuals. Bright intruders, being easier to detect, would not be able to feed as long before being expelled by an owner.

These results help explain why immatures are less brightly colored than adults. If the inexperience of immatures decreases their chances of owning a territory, they would benefit more than adults from the increased intrusion success that is associated with dull coloration. Not surprisingly, social structure during the nonbreeding season is related to age and sex; adult males tend to monopolize the best floral patches through territorial behavior. Females and immature males occasionally obtain territories, usually of low quality. More often, they survive on undefended resources or by stealing food from territory owners.

The explanations of dull immature plumage assume that the inexperience of immatures adversely affects their ability to defend territories and avoid predators. The gradual addition of bright feathers by immature males is consistent with this assumption; as immature males become more experienced, their chances of obtaining a territory and their ability to avoid predators should increase. Hence the net benefit of bright coloration should increase with age.

Viewing animals under natural conditions can be crucial for understanding the importance of bright coloration. For example, the bright green plumage on the back of Anna's hummingbirds seems to function in a manner exactly opposite to the bright feathering in the gorget region. Rather than announcing the bird's presence, it tends to conceal a bird perching amidst green foliage. Such concealment could be important for avoiding predation or for allowing territorial intruders to avoid detection by owners.

The high energy existence of hummingbirds and the patchy distribution of their floral food sources lead to a social system centered around aggressive interactions. Our present knowledge provides a glimpse of how environmental conditions and antagonistic behavior shape the structure of this simple society. We do not yet fully understand these relationships for hummingbirds, yet the unknown answers and alternative explanations are far from discouraging. They generate the excitement that causes periodic migrations of curious scientists back to their field sites, while providing the blueprints for future research. □

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Back to the Land

LIVING ON A FEW ACRES: THE YEARBOOK OF AGRICULTURE 1978. *Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. $7.00; 432 pp., illus.*

The United States Department of Agriculture has devoted its latest *Yearbook* to the problems faced by the very large number of Americans who live in towns or cities but spend a substantial part of each year on the land.

"Americans keep going back to the land," Secretary of Agriculture Bob Bergland writes in his foreword to *Living on a Few Acres.* "It is a pilgrimage that makes more sense to a lot of people than living in cities, enticing us with the promise of escape from freeways, assembly lines and crowds. The land offers freedom, a chance to test your mettle against nature's challenges.

"Now the tide of Americans that swept to the cities after World War II has ebbed. People are populating the countryside faster than they are cities. I know their motives. I am a farmer.

"This book . . . is a practical guide for those who make the journey back to the countryside and for some of you who are already there. It is mainly for those who intend not to gain their principal income from the land, but rather to have a job in town or live on a pension or some other source of income.

"*Living on a Few Acres* describes both the pitfalls and the satisfactions of country life. There are plenty of both. And there is nothing quite like country living."

Jack Hayes, editor of the present *Yearbook*, adds: "We have seen a great exodus from the land, and now we are beginning to see a substantial return. . . . Nonmetropolitan counties lost 3 million people through out-migration in the 1960s. But between 1970 and 1976, rural areas and small towns grew by 4.3 million."

Living on a Few Acres has 32 pages of excellent color photographs depicting various aspects of life in the country. The 432 pages of letterpress

George A Robinson

"If you have any doubts, ask one of the men who run sports fishing boats in the Gulf," says H. E. Braunig, a Manager of Environmental Affairs at Gulf Oil. "When they want to guarantee their customers a good day's fishing, they head straight for the oil platforms.

"Twenty universities and thousands of fish say oil platforms don't hurt the environment."

"What happens around the bottom of the oil platforms is ecologically identical to what happens around any natural reef.

"A food chain starts. Mussels, anemones, starfish, anything that likes to live on a solid underwater surface, all come first. Then the fish that feed on them; and so on, until a whole ecosystem builds up.

"Even with the oil platforms, it's life as usual in the Gulf of Mexico—even for the commercial shrimp and oyster fishermen, whose livelihood depends on clean water.

"That's living proof that offshore platforms aren't ecologically destructive. A two-year study by twenty Gulf Coast universities, concluded in 1974, says the same thing.

"Gulf people are meeting a lot of challenges in getting the oil out while preserving the environment. This problem just seemed to solve itself, and with continual environmental monitoring and sampling, on all current and future offshore sites, we intend to make sure it stays solved."

Gulf

Gulf people: meeting the challenge.

George A Robinson

and accompanying black-and-white illustrations that follow are divided into five helpful sections.

The book begins with a survey of the pros and cons of country living, of a distinctive life style with which the entire family should be in agreement. Those who go to the country must forgo many of the conveniences and facilities provided by the city and prepare to exchange multiplicity for elbow room. In each day of city living, more things are going on. But life in the countryside gives country dwellers a wider range of opportunity to do things in a manner and on a timetable they themselves can decide. Basic needs—food, shelter, clothing, personal services—most of which country dwellers can provide for themselves, are handled for urban dwellers by government agencies or by commercial establishments as impersonal as supermarkets and laundromats. In the city these basics are paid for by taxes, rents, and high prices, which a country dweller can avoid or lessen by doing his or her own work.

The *Yearbook* offers sage advice about purchasing or otherwise getting possession of a few acres. In the face of current inflation, land prices have gone up sharply in the countryside. I have been watching this development with much concern during the past few years and feeling thankful that I am under no compulsion to buy attractive farmland at present price levels.

Many people, privately and in public, have asked for advice on where to go for "a few acres." Here is my stock answer: Don't hurry. Take your time. Pick out a likely part of the country; go there and check on the spot. If you can afford a vacation, stay in your chosen locality for at least a few months. Note the weather; get the lay of the land. Talk with the people; get an idea of what neighbors you will have. Visit with real estate dealers; see what they have to offer. Attend farm sales. Read the local papers. When someone dies or moves away or offers land for quick sale or rent, get there fast and see for yourself whether you should buy or wait for something more desirable. If you are pressed for funds, do odd jobs. Offer to help or work as an apprentice to some knowledgeable farmer.

If you already have a few acres, add something to them with each passing month. Have a list of priorities. Improve your buildings, if any, and the land itself. If you choose wisely and persist in making obviously desirable improvements, the time will soon come when your land-strip will not only pay your annual tax bill but also contribute to your income.

A section on making the most of your land gives a wealth of suggestions worth studying and putting into practice. Its 242 pages are given over largely to concrete examples of country life, written in many cases by the participants—an actual how-to-do-it survey of experiences—well illustrated with black-and-white photographs, charts, tables, and detailed mechanical drawings. Unless you are an inveterate bungler or lazy half-wit, you will find many suggestions in this section of the book that will give first-class guidance and inspiration. You can hardly go wrong following one or another of the thirty tips on living on and working a small farm.

The last topic to be taken up is the disposal of property, which contains good legal and practical advice.

An important addition at the end of the *Yearbook* lists the various types of loans, grants, and other forms of assist-

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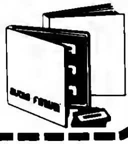

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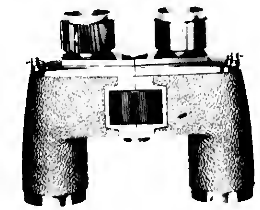

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ance that the Department of Agriculture is prepared to extend to prospective country dwellers, especially those on low income levels. I have never tested out the possibilities under this heading: "How to Get Help from the United States Department of Agriculture." I never spend money until I have it: no borrowing, no interest payments, no brokers' fees. But after reading through this section of generous offers, if I needed the help, I would certainly apply to Bob Bergland, Secretary of Agriculture, for necessary financing toward the acquisition of a place in the country.

I have been living on a few acres for a long time—almost three-quarters of a century. I began in a Single Tax colony in Arden, Delaware, in 1906, and after a lapse into city life, I continued

for two decades in Jamaica, Vermont (from 1932 to 1951), and in Harborside, Maine, from 1952 to the present day. Some of my experiences have been difficult and exacting; but most have been wonderfully satisfying. On balance, if I had it to do over again, I would follow much the same course and advise others to try it out. Life on a self-subsistent homestead can be exciting, rewarding, productive, educational. It is never boring.

Scott Nearing and his wife, Helen, have just published Continuing the Good Life: Half a Century of Homesteading *(Schocken Books). Nearing has been living off the land for almost three-quarters of a century. A dedicated educator, gardener, and farmer, he has written more than fifty books.*

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Celestial Events

by Thomas D. Nicholson

Sun and Moon Days begin to grow noticeably shorter in August as the sun shifts southward while moving east through the constellations Cancer and Leo, and then into Virgo in mid-September. Sunset will occur twelve hours after sunrise (the effective "equinox") by August 29 in Florida, by September 3 in New York and San Francisco, and by September 6 in Montreal.

The moon will brighten the evening sky for the first week in August and September, then gradually wane and move into the morning sky, emerging again as an evening object in the last week of each month. Phases in August are first-quarter on the 1st, full on the 7th, last-quarter on the 14th, new on the 22nd, and first-quarter again on the 30th. In September, full moon will be on the 6th, last-quarter on the 13th, new on the 21st, and first-quarter on the 28th.

Stars and Planets Jupiter and Saturn leave the evening sky in August and September and Venus and Mercury enter it. But only Saturn, in early August, is well placed for viewing. In the morning, you may find Mars easily, not very bright but rising early enough to be quite high before dawn. It will be an interesting object along with the crescent moon and Mercury from August 18 through the 22nd. Look for Mars near Pollux and Castor, the "twin" stars in Gemini, during the entire month of September, and near the crescent moon on the 15th and 16th. Jupiter, much brighter than Mars, will quickly become a prominent morning star the last week of September. Look for it near Regulus in Leo.

August 8: The perigee moon occurs 16 hours after full. Tonight's tides will be stronger than normal.

August 10: Mercury resumes its direct (easterly) motion.

August 11–12: The Perseid meteor shower (up to 50 per hour) will be best after midnight on these two days.

August 13: Jupiter is in conjunction with the sun and becomes a morning star.

August 16: The star close to the moon this morning is Aldebaran.

August 18–21: The crescent moon can help you see Mars and Mercury on these mornings. On the 18th, the moon will be near Mars, on the 19th between Mars (above) and Mercury (below), on the 20th above Mercury, and on the 21st below it.

August 25: Venus, at superior conjunction, becomes an evening star.

September 6: Today's full moon passes through the earth's shadow, producing a total lunar eclipse, visible in whole or in part throughout North America. The eclipse begins at 4:18 A.M., EST, and ends at 7:30 A.M., EST. The total eclipse begins at 5:31 A.M., EST, and ends at 6:17 A.M., EST.

September 10: Saturn, in conjunction with the sun, becomes a morning star.

September 12: An occultation of Aldebaran by the moon will occur over the eastern, central, southern, and southwestern United States from about 6:00 to 7:00 A.M., EST.

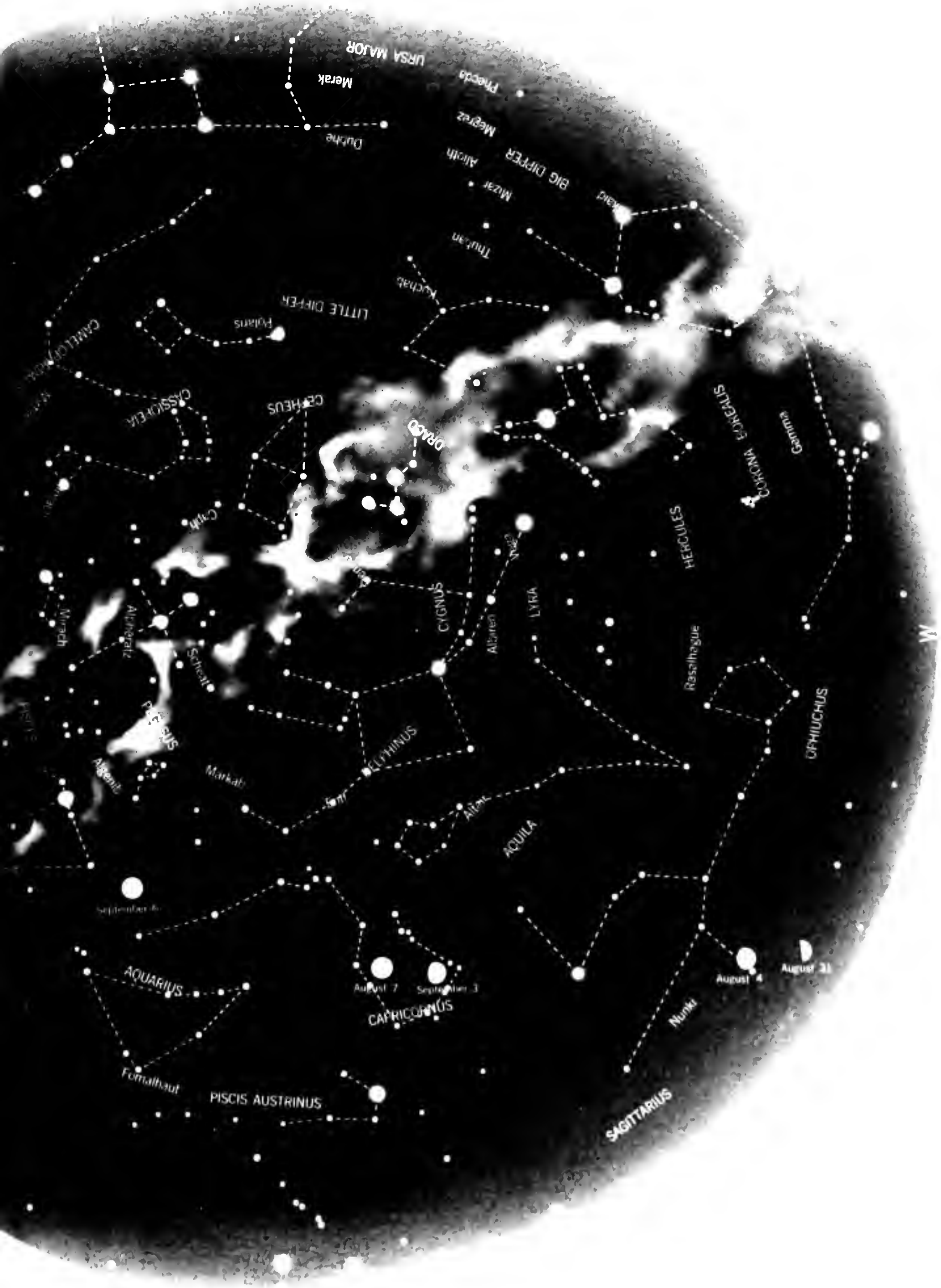
September 13: Mercury enters the evening sky.

September 16: The crescent moon is near Mars, Pollux, and Castor in the postmidnight sky.

September 18: The bright object near the moon this morning is Jupiter.

September 23: Autumn begins at 10:17 A.M., EST.

★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 12:25 A.M. on August 15; 11:20 P.M. on August 31; 10:20 P.M. on September 15; 9:20 P.M. on September 30; and 8:20 P.M. on October 15; but it can also be used for an hour before and after those times.



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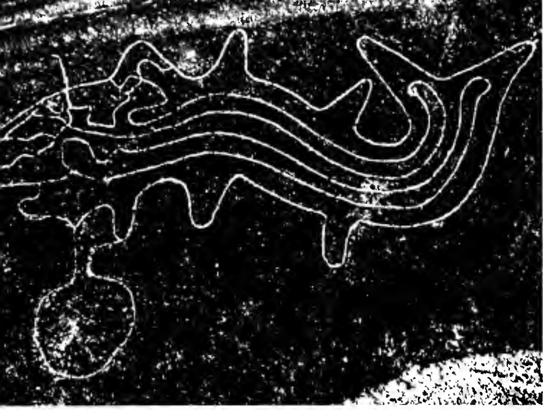
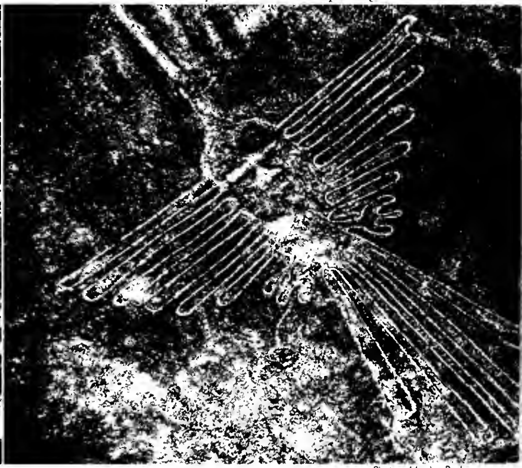


Aerial photography from 300 meters.

2000 year old Nazca pictograms: Peru.



Photos—Marilyn Bridges

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 by Stephen P. Maran

Counting the Sunspots

Despite different estimates of how many spots will appear, there is general agreement that the approaching maximum will be large

Despite at least six earlier forecasts of a weak sunspot maximum, it now seems likely that the sunspot cycle will reach a high peak this fall or winter. There already is much solar activity and the first major effects of the current cycle have been felt on the earth.

Solar activity comprises sunspots, solar flare explosions, and other disturbances on the sun. It increases and decreases cyclically, reaching maximum roughly once every eleven years. The spots are magnetically enhanced regions on the sun. Indeed, all forms of solar activity are probably related to distortions of one kind or another in the solar magnetic field.

Solar activity is associated with increased levels of X-rays and ultraviolet light from the sun, as well as with occasional intense bursts of these emissions and with streams of fast-moving atomic particles. The radiation and particles can reach the earth, where they affect the upper atmosphere and the earth's magnetic field. Among the principal effects is the heating of the upper atmosphere, which can, in turn, influence the motion of satellites such as *Skylab*.

Predicting solar activity, like forecasting the weather, is fairly successful only over periods of a few days. Long-range predictions are less reliable, and forecasts of the sunspot maximum made years in advance are particularly uncertain. Experts differ in their estimating techniques but nearly all the methods are statistical, rather than based on reasoning from physical theories.

As of late 1977, at least fifteen predictions of the forthcoming sunspot maximum had appeared. A summary prepared at the National Oceanic and Atmospheric Administration's Space Environment Services Center in Boulder, Colorado, shows that the predicted maximum dates ranged from 1978 to 1984. A half dozen forecasts looked for a very low sunspot maximum, with a sunspot number of only 50 to 60, but four predictions were for a rather high sunspot number of 130 or more. Since 1848, when sunspot counts became much more reliable than they previously were, the lowest sunspot maximum has been 64 (in 1907); the highest, 201 (in late 1957).

In addition to contradictory predictions, the terms used by sunspot counters are themselves confusing. For example, the sunspot maximum is defined by a mathematical procedure that averages the monthly sunspot number (itself an average of the numbers for each day of the month) over a period from six months before to six months after the month of interest. The month in which the highest sunspot number occurs is therefore not necessarily the peak month of the cycle. But this numerical procedure, which computes the so-called smoothed sunspot number, helps to avoid mistaking a brief episode of anomalously high sunspot activity—a solar flash in the pan, so to speak—for the actual maximum.

Predictions and comparisons with past sunspot cycles are made in terms of smoothed numbers. Many publications, however, list or use the daily and monthly sunspot numbers. And adding to the confusion, the daily sunspot number is *not* the number of sunspots seen on a given day. It is calculated from the number of spots, the number of groups of spots, and the record of each observer making a report that day. (Some astronomers have better viewing conditions and equipment and perhaps more imagination than others and thus tend to report more sunspots, while other observers seem to underestimate their sunspot counts.)

Three recent predictions of sunspot maximum are of particular interest. One, by a group of Stanford University astronomers led by Kenneth Schatten, is directly based on a physical theory of the sunspot cycle. According to this theory, called the Babcock Model for the Hale Observatories scientist who proposed it, there is a weak solar magnetic field at sunspot minimum, in which the magnetic lines of force run from pole to pole on the sun, making a pattern like the meridians of longitude on a globe. The differential rotation of the sun (surface features near the equator rotate more rapidly than regions at higher latitudes) gradually pulls the lines of force parallel to the solar equator, winding them up. Distortions of the lines of force then pop out in the form of small loops, much like the knots that appear as you wind up the rubber band in a model airplane. Sunspots form at the loops.

The Stanford astronomers note that since sunspots at maximum are derived from the magnetic field that was present at minimum, the intensities of the two phenomena may be directly related; that is, the stronger the solar magnetic field at sunspot minimum, the greater the number of sunspots that will form at maximum. From these ideas, they predict that the smoothed sunspot number at maximum will be 140. By separate means, they calculate that maximum will occur in December 1979.

The other two predictions of special interest emanate from the Space Environment Services Center. One of the Center's methods involves a comparison of smoothed sunspot numbers of the current cycle with the average behavior of many previous cycles. This method provides a new prediction each month as the latest observations are received. Thus it is reminiscent of the way in which the odds at a horse race

keep changing until post time. At last word, this technique predicted a smoothed sunspot number of 151 at maximum, to occur in November.

The final prediction method, espoused by SESC chief forecaster Howard H. Sargent III, depends on an apparent correlation of magnetic activity on the earth during sunspot *minimum* with the sunspot number at the next sunspot *maximum*. Therefore, like the Stanford astronomers' forecast, Sargent's prediction remains fixed once it is made. For the current cycle, he estimates a maximum number of 154, which he wrote me "will occur no earlier than November 1979 and probably no later than March 1980."

According to these three forecasts, which are consistent with the high degree of solar activity that has recently occurred, we are about to experience a very strong sunspot maximum. A smoothed sunspot number at maximum that exceeds 152 (the value for the maximum of mid-1947) would be the second highest in the systematic records kept since 1848. Thanks to the enormous recent growth in the use of citizens' band radios, effects of this sunspot maximum may be noticed by more people than any previous one. The enhanced ultraviolet radiation that accompanies solar activity increases the radio-reflecting power of the earth's ionosphere, thus extending the effective ranges of many kinds of radio transmissions. According to Sargent, who cites a study by the Office of Telecommunications of the U.S. Department of Commerce, "long-range interference from other citizens' band stations may severely limit the useful ground-wave range for citizens' band users."

Many other effects have occurred on the earth as solar activity has built up over the last two years. These include brilliant auroras over North America in late April and early May of 1978 after a large solar flare. One was so intense that a viewer in uptown Manhattan mistook an auroral ray for a searchlight beam. At about the same time, the Federal Aviation Administration was investigating the effects of solar activity on the navigation systems of aircraft flying international routes. Apparently, the FAA did not find a significant effect, but both Pan American and Trans World Airways had sunspot-related difficulties with high-frequency radio communications.

After a particularly large solar flare

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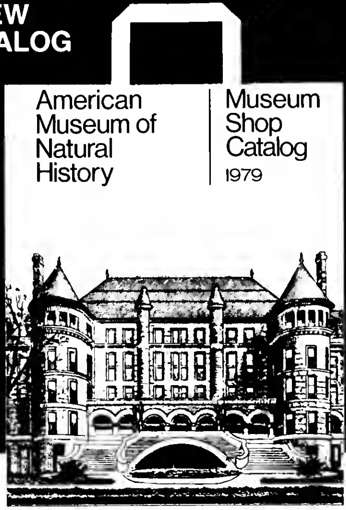

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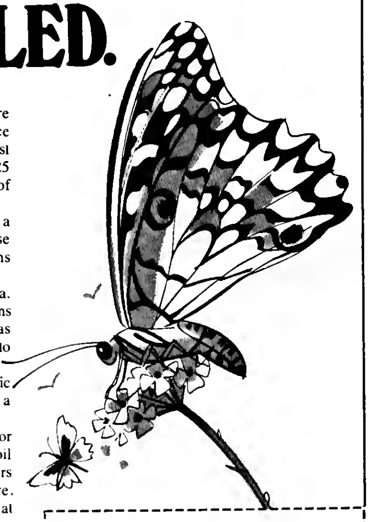

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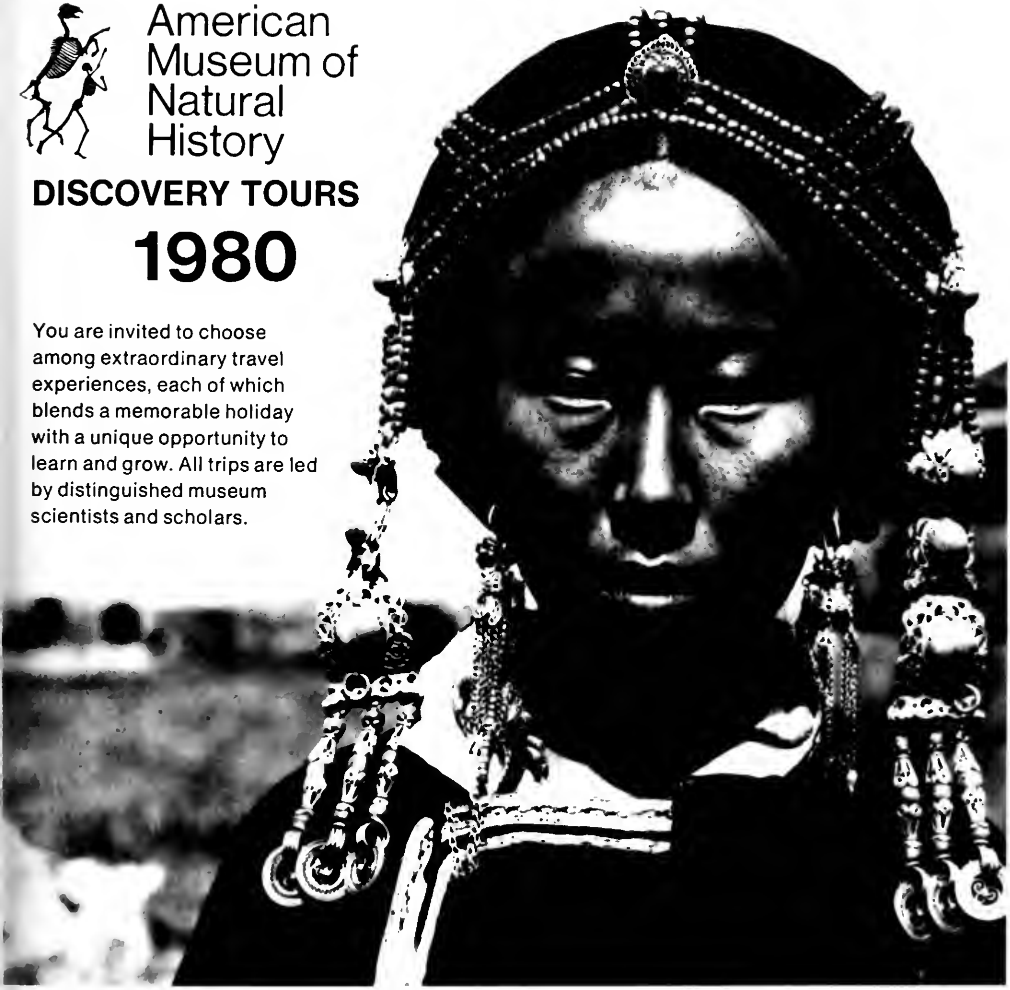

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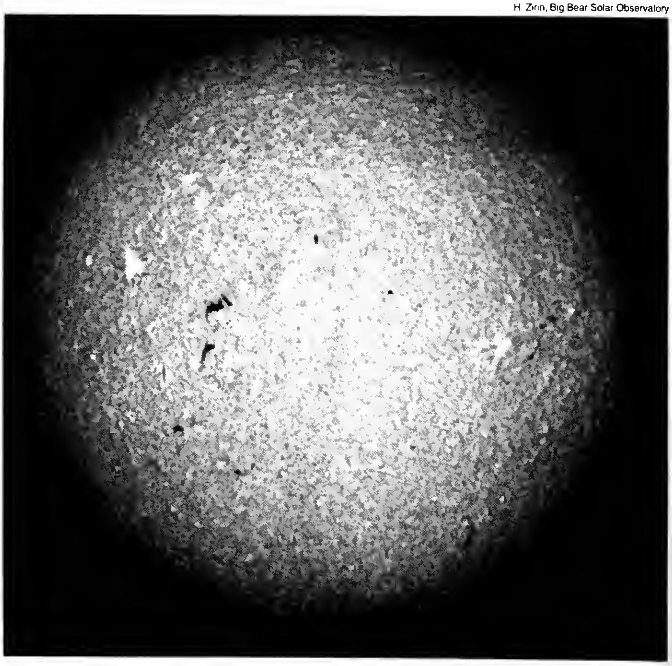

On January 29, 1976, a minimal number of "active" solar regions, where sunspots develop, was visible from the Big Bear Solar Observatory in California.

in July 1978, it was feared that atomic particles might reach the earth and endanger two Soviet cosmonauts aboard the space station *Salyut 6*. A warning was relayed over a direct line from the NOAA establishment in Boulder to the Soviet Union, and air controllers in New York were advised of a similar potential hazard to Concorde passengers. The high-flying supersonic aircraft carries automatic sensors and is therefore not wholly dependent on forecasts. When the sensors encounter excess radiation, an alarm is sounded and the pilot can direct the craft to lower altitudes where the atmosphere provides additional shielding.

In August 1978, geophysicists at the University of Alaska reported that they were developing ways to use NASA satellite measurements to provide a two-hour advance warning of auroras and related geomagnetic storms when substantial fluctuations occur in the earth's magnetic field. This ability may help the operators of radar, radio communications, and long-distance powerline facilities cope with the resultant interference. According to Louis Lanzerotti, a geophysicist at the Bell Laboratories in Murray Hill, New Jersey, when geomagnetic disturbances interfere with a transatlantic telephone cable, the operators can switch the traffic to a lower-latitude cable, which may be less affected, or to a communications satellite link. In addition to powerline disturbances and a blackout, which occurred in Canada as a result of solar-induced geomagnetic storms, Lanzerotti says that the storms induce electrical currents in the Alaska pipeline that sometimes knock out control electronics.

Other potentially serious effects of the current high solar activity were revealed in a syndicated article that appeared last September in the *Los Angeles Times*. The article said that the SESC is providing data on severe solar flares "by hot line" to the U.S. Air Force because of the possibility of solar-induced interference with vital over-the-horizon radar and spy satellites. On February 13, 1979, the same newspaper reported that emergency radio channels in southern California were being jammed by transmissions from distant points. In one case, a call was received for emergency aid at the

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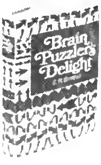

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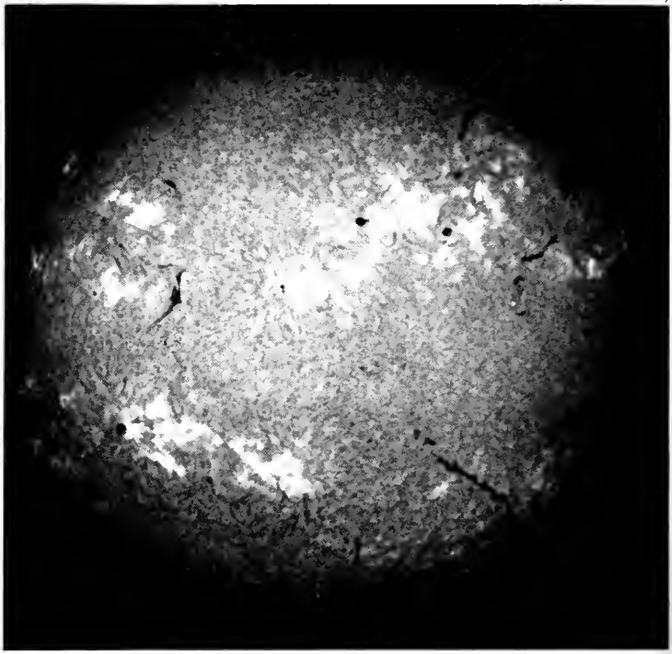

By January 26, 1979, the number of active solar regions had greatly increased. The current sunspot cycle would apparently reach a high peak.

scene of a commuter airline crash. The crash took place in Bridgeport, West Virginia, but the call was received by a fire department dispatcher in Orange County, California. A spokesman for the Los Angeles County Sheriff's Department said that patrolmen in the field were sometimes unable to get their own emergency calls through because of solar-induced interference.

In addition to the obvious effects of solar activity on the upper atmosphere, some scientists contend that it also affects the weather. These contentions, however, are for the most part unconfirmed and some are very dubious. Even further afield, a British researcher on epidemiology claimed last year that "the periods of world dominance of successive major subtypes of influenza A virus have synchronized closely with the periodicity of sunspots." Correlations of biomedical phenomena with solar activity, such as this one, are generally not taken seriously by most Western scientists. Many researchers in the Soviet Union, however, do believe in such possibilities, including even a correlation of sunspots with outbreaks of plague-spreading rodents in central Asia.

For the immediate future, investigators are concentrating on learning more about solar activity and how the associated radiation interacts with the earth's environment. A Solar Maximum Year of worldwide coordinated studies, running from August 1979 through February 1981, has been arranged. Numerous ground-based optical and radio telescopes and satellite observatories are involved in the research. In October 1979, NASA will launch the largest unmanned solar research satellite yet built, the Solar Maximum Mission, and from a control facility at the Goddard Space Flight Center, scientists from several nations will direct its battery of instruments at disturbed regions on the sun. Thus, whether or not the sunspots behave as predicted, the coming maximum will be the best-studied solar maximum in history.

Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

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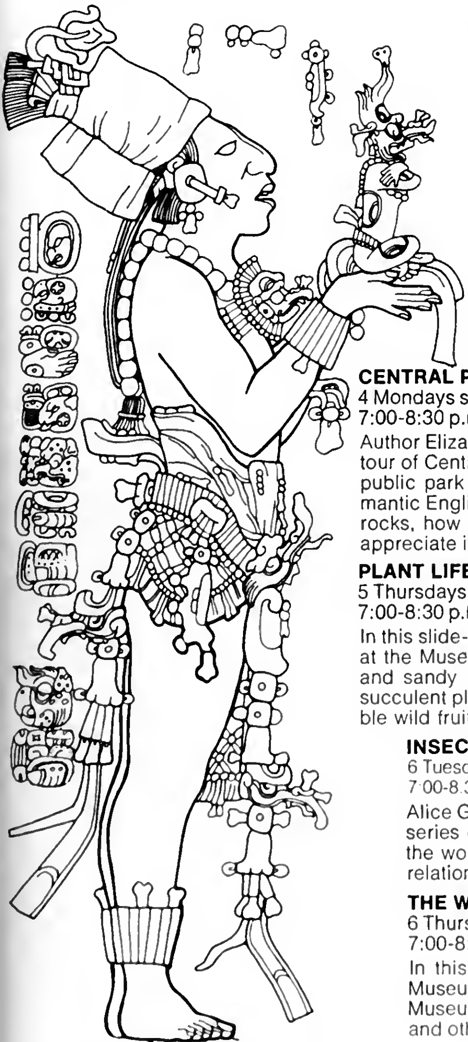

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Additional Reading

Oil-eating Bacteria (p. 42)

"Phosphate Replacements: Problems with the Washday Miracle," by A.L. Hammond (*Science*, vol. 172, 1971, pp. 361–63), explains how phosphates in detergents cause water pollution. How bacteria can be used to fight the ecological ill-effects of oil spills is the subject of "Sequential Growth of Bacteria on Crude Oil," by A. Horowitz, D. Gutnick, and E. Rosenberg (*Applied Microbiology*, vol.

Immature male black-chinned hummingbird

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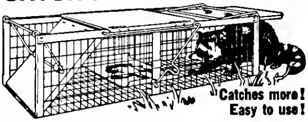

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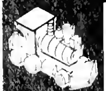

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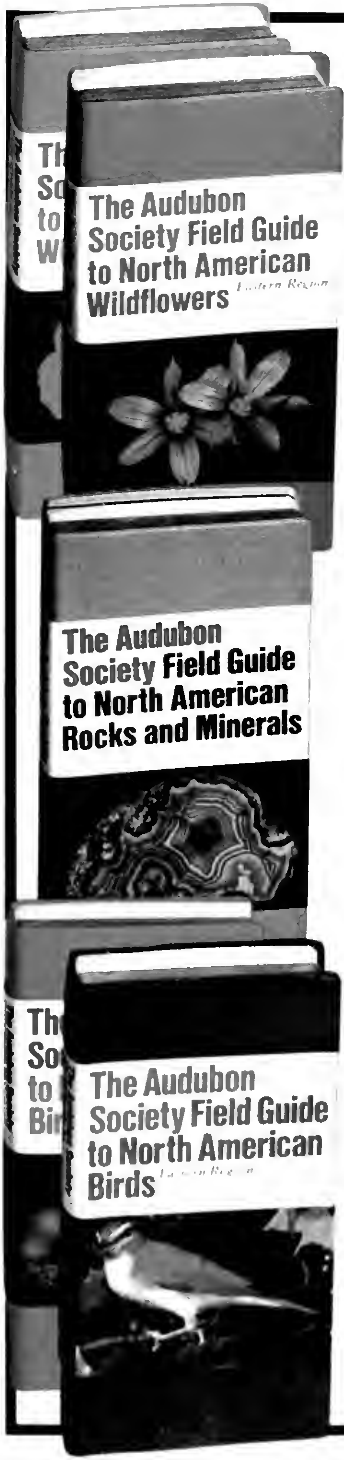
30, 1975, pp. 10–19). *Petroleum Microbiology*, by John B. Davis (New York: Elsevier, 1967), is a more extensive general discussion of the same subject and includes an extensive bibliography.

Carnival (p. 72)

A collection of short stories and excerpts from the works of West Indian writers can be found in *Caribbean Rhythms: The Emerging English Literature of the West Indies*, edited by James T. Livingston (New York: Washington Square Press, 1974). *Peoples and Cultures of the Caribbean: An Anthropological Reader* (Garden City: Natural History Press, 1971) has a chapter entitled "Carnival in Nineteenth Century," by Andrew Pearse (pp. 528–52). "Slaves' Holiday," by Robert Dirks (*Natural History*, December 1975, pp. 82–90), discusses the threat of rebellion that lurked behind Jamaican slaves' New Year's celebrations in the nineteenth century.

Ramapithecus (p. 86)

"Behavior and Human Evolution," a chapter in *Classification and Human Evolution*, edited by Sherwood L. Washburn (Chicago: Aldine Publishing Co., 1963, pp. 190–203), describes the structural bases for motions and postures shared by man and ape. Writing before much biochemical data were available, the author suggests a late, rather than early, separation of ape and man. Molecular evidence for determining relationships of living primates and for estimating times of divergence is discussed in "Molecular Systematics of the Primates," an ar-



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ticle by Sarich and Cronin in *Molecular Anthropology: Genes and Proteins in the Evolutionary Ascent of the Primates*, edited by M. Goodman and R. Tashian (New York: Plenum Publishing Corp., 1976, pp. 141–70). Two articles by Elwyn Simons are of interest. "On the Mandible of *Ramapithecus*" (*Proceedings of the National Academy of Sciences*, vol. 51, no. 3, pp. 528–35) points out the difficulty in distinguishing *Ramapithecus* from *Australopithecus*. In "*Ramapithecus*" (*Scientific American*, May 1977, pp. 28–35), Simons reaffirms that *Ramapithecus* is a member of man's family tree, based on the finding of many new specimens. *Paleoanthropology: Morphology and Paleoecology* (Chicago: Aldine Publishing Co., 1975), edited by R. H. Tuttle, includes an article by G. Conroy and D. Pilbeam: "*Ramapithecus*: A Review of Its Hominid Status" (pp. 59–86). The authors maintain that *Ramapithecus* is a hominid, the biochemistry notwithstanding.

Hummingbirds (p. 92)

"Food Supply and the Annual Cycle of the Anna Hummingbird," by F. G. Stiles (*University of California Publications in Zoology*, vol. 97, 1973, pp. 1–109), presents the results of a three-year study of the role of food supply in hummingbird territorial behavior, breeding, and seasonal movements. Carried out in the Santa Monica Mountains of California, the study encompasses both natural and man-altered habitats. In "Aggressive Social Organization in Nectarivorous Birds," L. L. Wolf suggests a model, based on the net benefits of one behavioral form over another, for determining whether an organism should be territorial or not (*American Zoologist*, vol. 18, no. 4, pp. 765–78). The ability of hummingbirds to regulate their metabolism for survival is discussed in "Energy Crisis of the Hummingbird," by William A. Calder III (*Natural History*, May 1976, pp. 24–29). *Hummingbirds and Their Flowers*, by Karen A. Grant and Verne Grant (New York: Columbia University Press, 1968), is about pollination of flowers by hummingbirds. *Hummingbirds*, by W. Scheithauer (New York: T. Y. Crowell Co., 1967), offers tips on photography, advice on keeping hummingbirds, information on flight, feeding, breeding, and nesting, and is illustrated with seventy-six color photographs.

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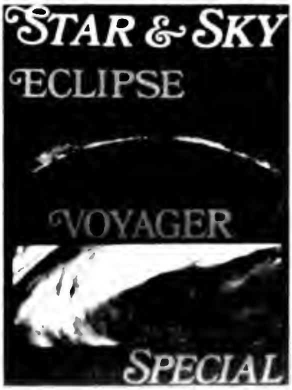

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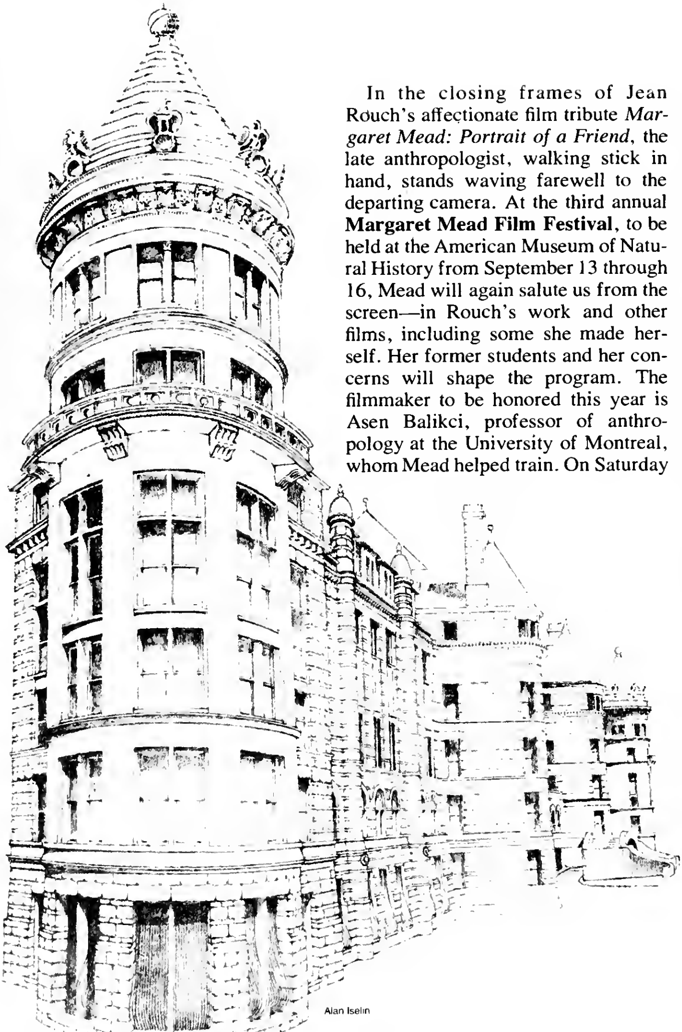


Alan Iselin

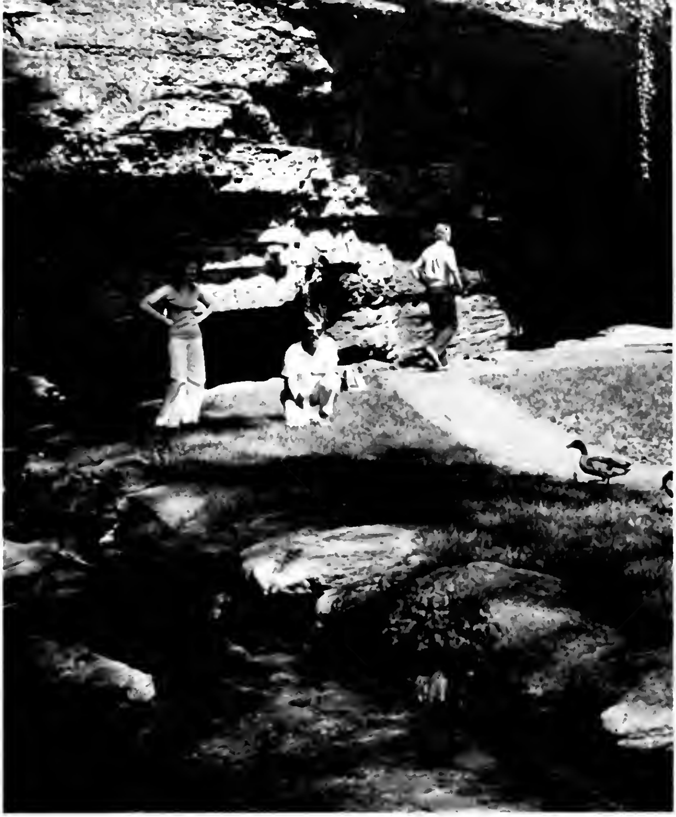
In the closing frames of Jean Rouch's affectionate film tribute *Margaret Mead: Portrait of a Friend*, the late anthropologist, walking stick in hand, stands waving farewell to the departing camera. At the third annual **Margaret Mead Film Festival**, to be held at the American Museum of Natural History from September 13 through 16, Mead will again salute us from the screen—in Rouch's work and other films, including some she made herself. Her former students and her concerns will shape the program. The filmmaker to be honored this year is Asen Balikci, professor of anthropology at the University of Montreal, whom Mead helped train. On Saturday and Sunday, September 15 and 16, an exultation of anthropological films organized by Mead's former colleagues will be shown in nine sections whose titles reflect her particular interests: Childhood, The Family, Cultural Change, The Spirit World, Oceania, Urban Life, American Culture, Early Ethnographic Film, and New Films.

The Festival annually commemorates Mead's pioneering use of film in fieldwork and the support she gave younger anthropologists and filmmakers who wanted to do likewise. A lifelong moviegoer, especially fond of films about family generations, she began making films in the 1930s, when she and Gregory Bateson were working in New Guinea and Bali. (He held the camera; she took accompanying notes and occasionally made an appearance.) In its various sections, the Festival program will show almost the complete oeuvre of Mead and Bateson, as well as *Margaret Mead's New Guinea Journal*, which records her return visit in 1967.

In spite of Mead's sterling contributions, until recently women have made surprisingly few anthropological films. This year's Festival will present many female filmmakers, and a good number of films, by directors of either sex, that concentrate on women, whose stories, Mead always reminded her audiences, are as important as other aspects of a society. The Family sec-

tion includes the first home movie, by one of the earliest *cinéastes*, Louis Lumière. *Le dejeuner du bébé*, featuring Lumière's own child, demonstrates that the family is perhaps the oldest cinematic subject. In *Growing Up in Paradise*, also part of the Family program, Canadian-born Sandy Wilson edited her family's home movies and used their comments on the sound track. Other filmmakers' versions of life in the bosom of the family appear in Hollywood director Martin Scorsese's *Italian American*, a gentle, humorous portrait of his parents, which concludes with his mother's recipe for spaghetti sauce, and in one segment of "An American Family," a television documentary about the Louds of Santa Barbara, which Mead greatly admired.

While planning the American Culture section, Malcolm Arth, the Museum's curator of education, found that "anthropologists seldom had made films about the United States; with few exceptions, they concentrated on remote parts of the world." To fill the gap, he chose filmmakers' contributions that would be useful to anthropologists. The most moving is probably *A Day in the Life of Betty Consolo*, a 1976 Academy Award nominee about a woman, now a wife and mother, born with no arms. Thanks to her almost boundless good humor and courage—not to mention dexterous feet—she manages to market, drive,



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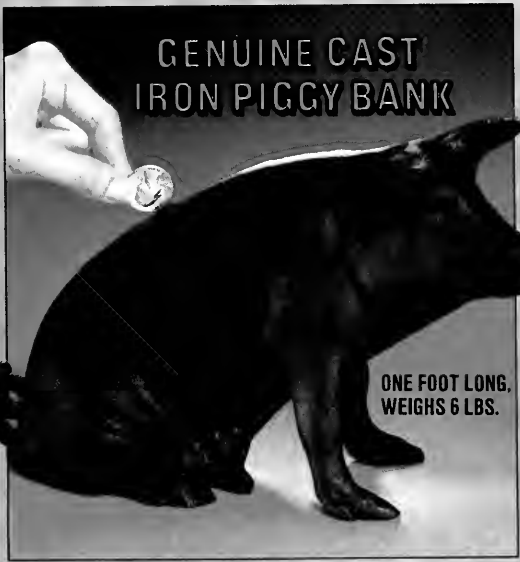

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talk on the phone, and keep house as well as any person without handicaps.

This year, as always, we anticipate much comparison, argument, and lines drawn over the relative merits of films by anthropologists and those of filmmakers. The Early Ethnographic Film program will present an example of the work of Hungarian-born Paul Fejos, the only commercial filmmaker, with Hollywood credentials, who ever became an anthropologist. The Festival luminary, Asen Balikci, is one of the few well-known contemporary ethnographic filmmakers who are trained anthropologists. He will present some of his films on September 13 and 14 at 7:30 P.M. in the Auditorium.

Born in Istanbul of Slavic Macedonian parents, Balikci emigrated to Canada in 1954. As an anthropology student at Columbia University, he took Mead's course in field methods in 1959. "We didn't use video then," he recalled, "but she encouraged us to work with a 16-mm camera." She was in favor of filming continuously, avoiding cuts, in order to record whole sequences of behavior. She also admonished her students to step back from the action, to photograph a person's whole body, not just the face. Balikci and his fellow students filmed at a sand pit near Columbia frequented by mothers and children from the multiethnic community of New York's Upper West Side. "We made running records, minute-by-minute descriptions of behavior. One student held a

16-mm camera, one a still camera, a third a tape recorder. Later, we would abstract patterns of behavior from what we recorded."

From 1963 to 1965, Balikci made a series of nine films on the Netsilik Eskimo, who survive by fishing and hunting seals along the Arctic coast northwest of Hudson Bay. The Netsilik films have been used in "Man: A Course of Study," an ambitious yearlong curriculum that introduces anthropology to elementary school students. On the evening of September 13, Balikci will show two parts from this series, about life at the Netsilik winter camp on the sea ice, where families hunt for seals' breathing holes and cut blocks to construct igloos. By the mid-1960s, the Eskimo had largely abandoned traditional life, but Balikci and his film crew managed to persuade them to reenact their old ways. This program will conclude with a brief film on their present condition, in which former customs have been replaced by white bread and snowmobiles.

Seeking a contrast to the gentle Netsilik, Balikci found the Pashtoon, the tough, independent, pastoral nomads of Afghanistan, Kipling's "wily Pathans." On September 14, he will screen and discuss *Sons of Haji Omar*, which he and Timothy Asch completed this year. Besides taking into account

Pashtoon children gather for the camera in Sons of Haji Omar.

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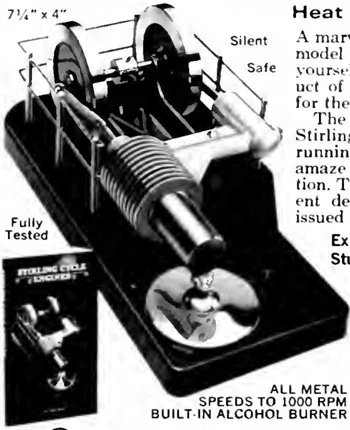

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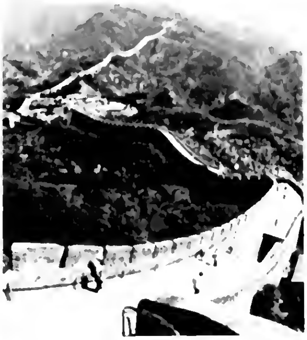

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Asen Balikci's new film, Sons of Haji Omar, *describes the nomadic life of the Pashtoon of Afghanistan.*

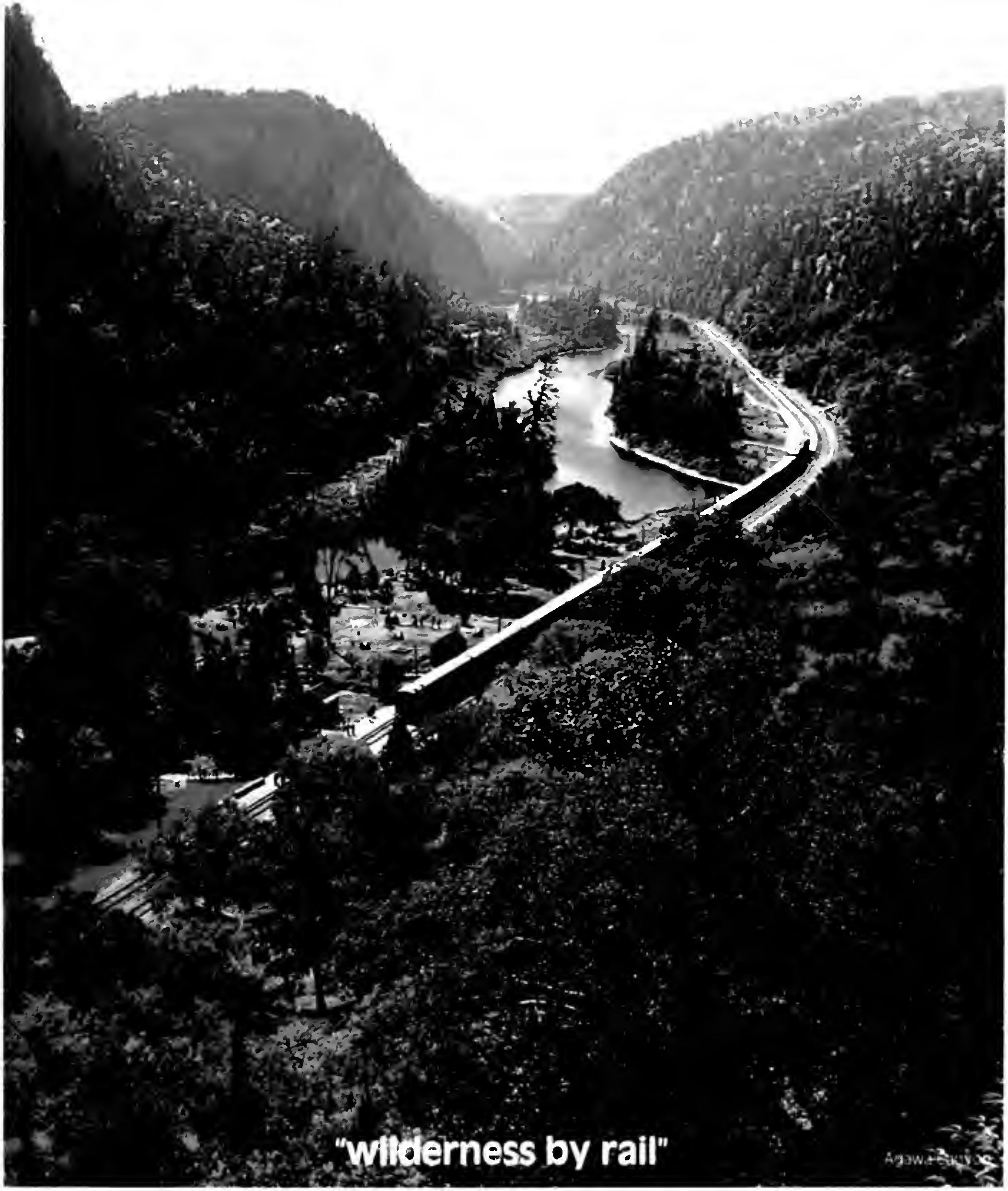
the best ways to teach anthropology, Balikci concentrates on how a people organize themselves to survive in a certain environment. What he calls "basic adaptive strategies" are those activities that can be easily translated to film, unlike more esoteric concerns such as religion.

Tickets for both evenings with Asen Balikci cost $8 for Participating and Donor Members, $10 for the general public. Complete Festival programs will be available at Museum information desks as of the first week in August. For further information about the Festival call (212) 873-4737.

Museum Events

On August 1, the Membership Program will be a 1928 silent film that is a grandparent of Balikci's accomplishment among the Netsilik. *The Silent Enemy*, directed and produced by the late W. Douglas Burden, a former trustee of the American Museum, reconstructs the Ojibway Indians' trek west of Hudson Bay to the "barren lands" where herds of caribou were plentiful. En route, the film attempts to depict the traditional life that the Ojibway, whose members were being decimated by flu and pneumonia, had largely abandoned. Burden used Indian actors; only a few of them had ever seen a film or could speak fluent English. The producer chanced upon his star, Chauncey Yellow Robe, a striking full-blooded Lakota chief, as he browsed among the Indian exhibit cases in the Museum. Children's book author Rosebud Yellow Robe, the star's daughter, will be on hand to discuss the film when *The Silent Enemy* is shown in the Auditorium at 7:30 P.M. Public admission is $2.00.

Ann Marie Cunningham



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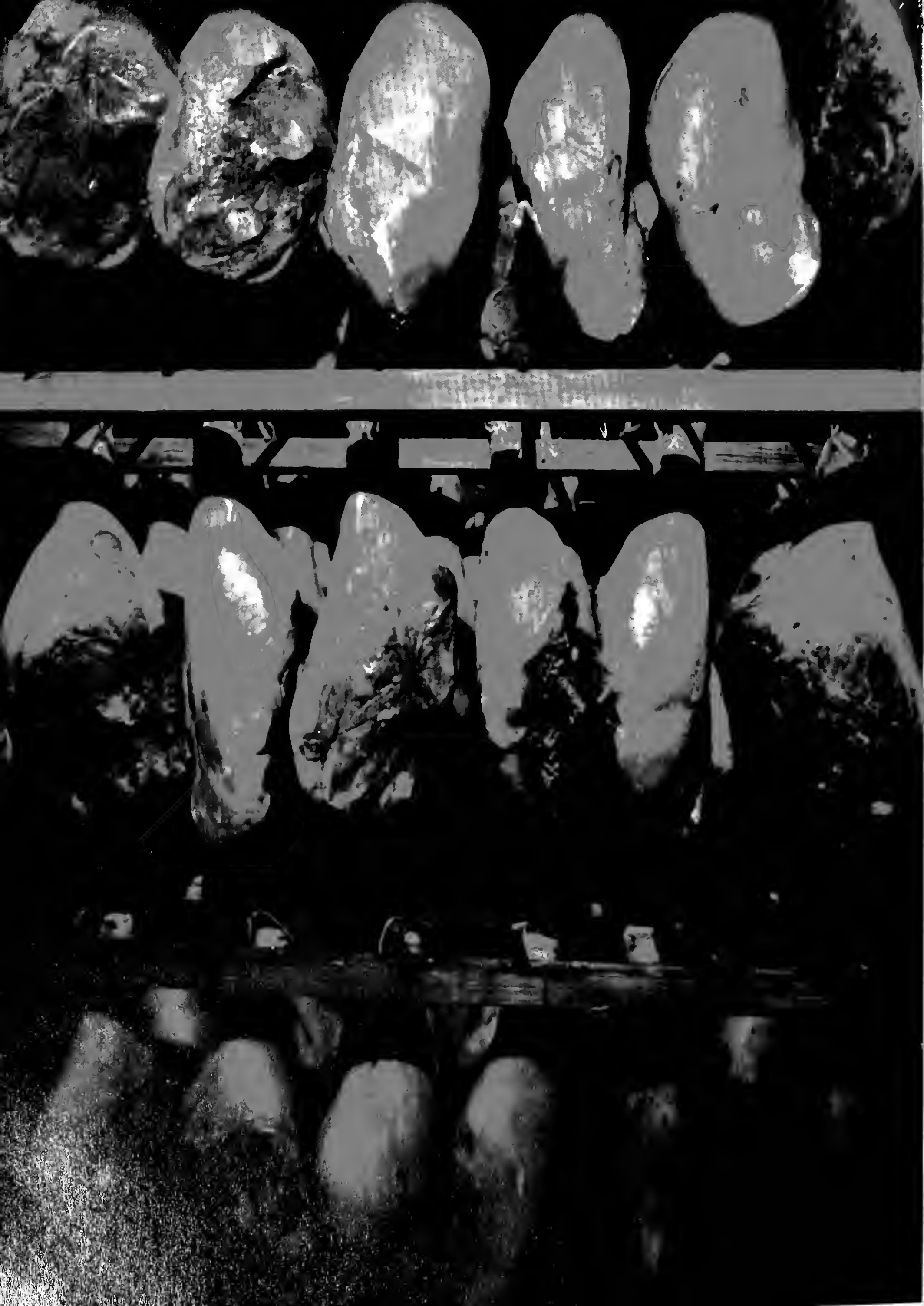


Living High off the Hog

Smithfield, Virginia, is still the source of fine old-style country hams

Parke Griffin passes the shaft of an ice pick slowly under his nose. He inhales gently, concentrating as he sniffs. Then he smiles. Griffin is not a homicidal maniac savoring his murder weapon; he is a 61-year-old, tobacco-chewing Virginia farmer testing a country ham. Like his "one-horse" farmer father and generations of other rural folk in the American South, Griffin cures his own hams, smokes them, and then ages them over the summer until they turn dark red and take on a virile tang. The process is crude, does not involve refrigeration, and has been part of human life for as long as there have been hogs and salt. But it is also a subtle method, a gamble against weather, a matter of intuition and experience, a canny fight with bacteria. Parke Griffin is smiling because he is winning his bet.

The ice pick is his "test instrument." He hones it and probes deep into the ham where it was cut from the haunch of a hog back in January. After a lifetime of testing country hams, he can detect spoilage as easily as a Bordeaux shipper can spot a bad vintage. The long, flat, streamlined, pepper-coated ham he has taken down from the rafters of his smokehouse is doing fine. By Thanksgiving, it will be perfect.

With 1,200 mandolin-shaped hams hanging in several aromatic tiers in two smokehouses behind his spruce- and myrtle-shaded house, Griffin is the very picture of a successful small entrepreneur. He will gross roughly $30,000 from this sideline, but he thinks of himself, correctly, as one of a vanishing breed of old-time ham men. Very few farmers in today's mechanized, competitive agricultural market have the time or the knowledge to cure country hams themselves. And those who do are hemmed in by official regulations that, in effect, keep them from competing with the four packing houses in Smithfield, Virginia, or with other big commercial packers that mass-produce old-fashioned country hams. Griffin himself buys "green" (fresh) hams from the packers in Smithfield, the country ham center, a few miles from his house. It wouldn't pay him to comply with federal inspection rules so that he could sell pork he had slaughtered himself. As it is, he can sell his hams only in Virginia, not through the mails or any other avenue of interstate commerce. Indeed, he cannot even sell his hams in local stores or have them sliced on another retail merchant's slicing machine. None of these restrictions keep Griffin from selling out his stock, but they have tended to discourage most farmers from putting money into hams, especially into hams that must hang for a minimum of six months while inflation erodes their value.

Curing hams the old way is also a lot of work. Griffin begins in January. He sets out scalded wood salting racks on the floor of his smokehouse. On these racks he lays out one hundred hams at a time, lays them out flat, with the "face" (the cut side) up, then sprinkles on a small amount of saltpeter. Griffin says he uses only four ounces of saltpeter per hundredweight of ham and lets it soak in all day "until dinner." (Saltpeter colors ham, bacon, and other prepared meats red. It is under heavy attack as a cancer agent, but pork producers, who defend it as a protection against botulism, argue that it has been in common use for centuries, does not present a provable threat to health in normal use, and should not be banned.)

Next, Griffin packs his ham in salt, ordinary table salt that he buys in eighty-pound bags. Some people use flake salt, which does not roll off the ham. In either case, the method is the same, a dry cure.

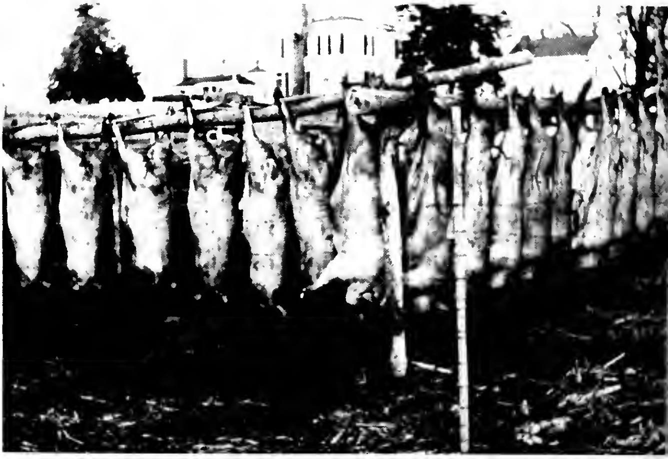
Old-style country hams, and also Italian prosciutto, are not soaked in brine (salt dissolved in water). They undergo a slower cure with dry salt, which has to dissolve in the ham's natural moisture and therefore penetrates pork more slowly than brine. The dry cure is also riskier because it gives bacteria a better chance of acting if the weather turns suddenly warm. But proponents of Smithfield-style hams and of prosciutto both assert that dry curing is a more refined method that yields a ham of supreme character. Prosciutto is, however, much more lightly salted than Smithfield ham; it is cured in the mountains outside Parma where the constant cool weather and altitude co-

Hams that have been cured and smoked are hung from the rafters of a Tidewater Virginia smokehouse until they acquire a dark red color and a strong, tangy taste.

...ade de Menil

Until the 1950s, hog slaughtering at Berry Hill Farm was a communal ritual. The freshly killed hogs were hung on the gallows overnight to chill and remove animal heat before being butchered and trimmed.

Nancy Warner Dashie



operate in lowering the level of natural bacterial activity.

In Smithfield, once a prospering port, the warm climate and low altitude oblige heavier salting. All Smithfield country hams are liberally covered with salt and left to cure for a few days. Parke Griffin generally waits five days. Nancy Warner Dashiell, whose brick smokehouse at nearby Berry Hill Farm is more than two hundred years old, waits only four days. At any rate, during that time, the hams "drink" most of the salt. The floor of the smokehouse fills with natural brine that drips down from the hams.

After this first salting, the hams are salted again and left for three to five weeks, depending on the weather. In warm weather, the hams take the salt faster and are cured for a shorter period. Obviously, longer salting gives a saltier final taste. Different palates prefer different degrees of saltiness. In any case, all American country hams are salty, much saltier than prosciutto. But this is only part of the difference between these hams. After it has finished curing, prosciutto is simply hung to dry for six months in the mountain air and then eaten raw.

American country hams, which are normally eaten fully cooked, are much more thoroughly treated than prosciutto. After the curing period ends, the hams are washed off with hot water to remove the salt, then pepper is rubbed into the faces of the hams to seal them off from infection and insect infestation. Finally, they are hung high in the smokehouse, hung carefully so that they do not touch each other, which would cause "bad spots." When the hams have dried for a few days, smoking begins.

The various ham experts I talked to in and around Smithfield each had a different, personal approach to smoking, but they all burned some kind of hardwood—apple, red oak, or even fallen pecan boughs—smothering the fire with wet sawdust and taking their own good time about it. Nancy Dashiell says, "I smoke the meat three times a week, alternating days, for two weeks, then twice a week for a month until it has a good brown color."

Davis Lee Godwin and Tip Spivey, two old farm boys who cure hams in Windsor, Virginia, as a hobby—and a memorial to their youth, when they would trade home-cured hams for groceries during the cash drought of summer—both think that the slow smoking and "individual handling" they give their hams makes them superior to packers' hams. They also favor extremely long hanging, one and a half years or longer, so that the meat ages to an extreme density, turns very red, "marbleizes," and acquires a strong tang.

I was able to buy the last of their 1978 hams, an eighteen-month-old beauty. It was coated with a patina of green mold, a harmless badge of venerability that sometimes fools ham neophytes into throwing out a precious old treasure. I soaked mine longer than standard directions call for (see recipe below), for a day and a half. Because Smithfield hams are long and flat, it took a very large pot to facilitate the cure. They also come with the hock, the long narrow bone just above the foot, still attached. I cut off the hock and used it in pea soup so that I coulc fit the main part of the ham into my biggest pot. Soaked and slowly cooked, the ham emerged beautifully tender, deep red, and with a taste of powerful sophistication. Was it bettei than the packers' ham I had tasted at the Wakefield Virginia Diner in Wakefield, a twenty-minute drive from Smithfield? Or the razor-thin slices of estimable ham they serve at the charming old Smithfield Inn, that shrine of Tidewater Virginia cuisine? This is obviously a matter of taste. Perhaps have not been eating country hams frequently enough or long enough to have formed a clear bias. I liked all those hams. Each one had the flavor impac and directness of a young, rural, pioneer country. Moreover, they all hac the paradoxical combination of innocence and refinement that comes from two centuries of practice with an inherently primitive technique. It did nevertheless, seem to me that the ol ham from Godwin and Spivey's smokehouse had something extra, the complexity of taste that, in its entirely different way, a carefully handled grea wine can display.

This is certainly the feeling of old time farmers around Smithfield, wh have watched their way of life erod over the last fifty years, while the pack ing houses grew into big business. A Berry Hill Farm, which adjoins th Gwaltney packing house, the 300 year-old communal ritual of hog kill ing continued in the old way until th 1950s. Hogs were slaughtered, hun on gallows to cool, then butchered an trimmed. Lard was rendered in bi pots. Nothing was thrown away, fror

Adelaide de Menil

The Berry Hill Farm smokehouse, left, is more than two hundred years old. The farm now adjoins a modern packing house, but the smokehouse still has hams for the family's use.

Since dry curing hams is a slower and much riskier process than curing them in brine, Parke Griffin must continually probe his pepper-coated hams with an ice pick to check for any signs of spoilage.

snout to tail. Nancy Dashiell still supervises hog slaughtering for family use, and in her smokehouse, you see not only hams and sides of bacon but also jowls (pronounced "joels" locally) hung by the tongue with the teeth gleaming in the half dark. But the almost tribal ceremony of hog slaughtering is now only a memory from the recent past.

"Then," writes another Smithfield woman, Mrs. Dewitt Griffin, "people worked by the sun and not by the clock and they worked hard so by the time they could eat, they were really hungry. I baked my pies beforehand, and then each day I made large pans of potato pudding, cooked beans, cabbage, and snaps and made cornbread and biscuits to serve with the fresh pork. Everything was eaten, which made me feel good."

Until the twenties, Smithfield was not a major packing center. It was the national peanut capital. But the peanut warehouses burned in 1921, and nearby Suffolk, with its better rail connections, forged ahead as a peanut entrepôt. Smithfield then fell into the big-time ham business almost by default. By 1939, the Gwaltney family and other packers had developed a modern meat packing industry with dry-cure, aged ham as its emblem.

In the early days of the Smithfield packing industry, farmers would slaughter their own hogs and bring them to Smithfield on flat wagons, hundreds of carcass-laden wagons waiting in line. Federal meat regulations have ended all that, and the packing houses now do their own slaughtering. Each week 90,000 hogs are turned into pork

at the two largest packing plants.

Very little of this meat is made into traditional Smithfield hams. At Gwaltney's, now a subsidiary of ITT, only about 50,000 of the company's annual total of more than two million hams are prepared in the canonical way. The Smithfield ham market is a special market. But it is to the Gwaltney company's credit that it persists with its country ham operation in a special building with a gigantic internal wood smokehouse. The old methods are followed with religious devotion and supervised by a Smithfield veteran who has a testing ice pick in his office and who has insisted on traditional techniques despite some initial meddling from the corporate headquarters in Rye, New York.

Have precise temperature controls and mass production in the packing plants cut into the quality of Smithfield hams? Not as far as I could tell. More pertinently, in the opinion of the white-haired butcher who runs the folkloric meat department of West's Supermarket at the end of Smithfield's Victorian main street, packers' old-cure hams are just fine. Although he sells hams he cures himself (as well as cured jowls and tails), the butcher also sells packers' hams and doesn't have a bad word to say about them.

If the country ham is an endangered species, it is not the fault of anyone in Smithfield. It is the result of changes in the outside world, of a new national taste formed by square, water-cured hams in cans, and of naïve people who throw away gift Smithfield hams because they find them too salty. Meanwhile, the old rural life around Smithfield may be vanishing. A newly widened highway will soon bring more commuters from Newport News twenty miles away. Despite these menaces, the Smithfield ham still hangs on as a savory relic of America's early days. Parke Griffin is still spry enough to perch in his smokehouse rafters in a cloud of pepper babying his hams. And at least one old-fashioned Smithfield ham will probably survive into the age of fusion. It is seventy-seven years old, woody and inedible, but still intact. One of the Gwaltneys took it with him when ITT bought him out. It is now installed in the office at his Chevrolet dealership, a wizened symbol of the world we are losing.

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

Adelaide de Menil

Mrs. Syke's Smithfield Ham

"Wash a Smithfield Ham in hot water with a stiff brush. Soak overnight in cold water. Put in a boiler of water large enough for ham to float. When it gets to the boiling point, turn flame low, so it won't even bubble. Cook until bone on large end leaves ham (about one inch). Then take out of the boiler. Don't leave it in the water to cool. When cool, skin and trim off some of the fat. Put in hot oven so it will brown in 10 minutes."

Howard Gwaltney's Smithfield Ham and Crabmeat Casserole

1. Preheat oven to 350 degrees.
2. Cover the bottom of an oven-proof dish with a layer of cooked, thin ham slices.
3. Cover with about one inch of cooked crabmeat.
4. Add a top layer of ham slices and place in oven.
5. Cook for about 20 minutes, until the ham juices mix thoroughly with the crabmeat. Serve hot.

(Recipes reprinted from *The Smithfield Cookbook*, published by the Junior Woman's Club of Smithfield, Smithfield, Virginia)

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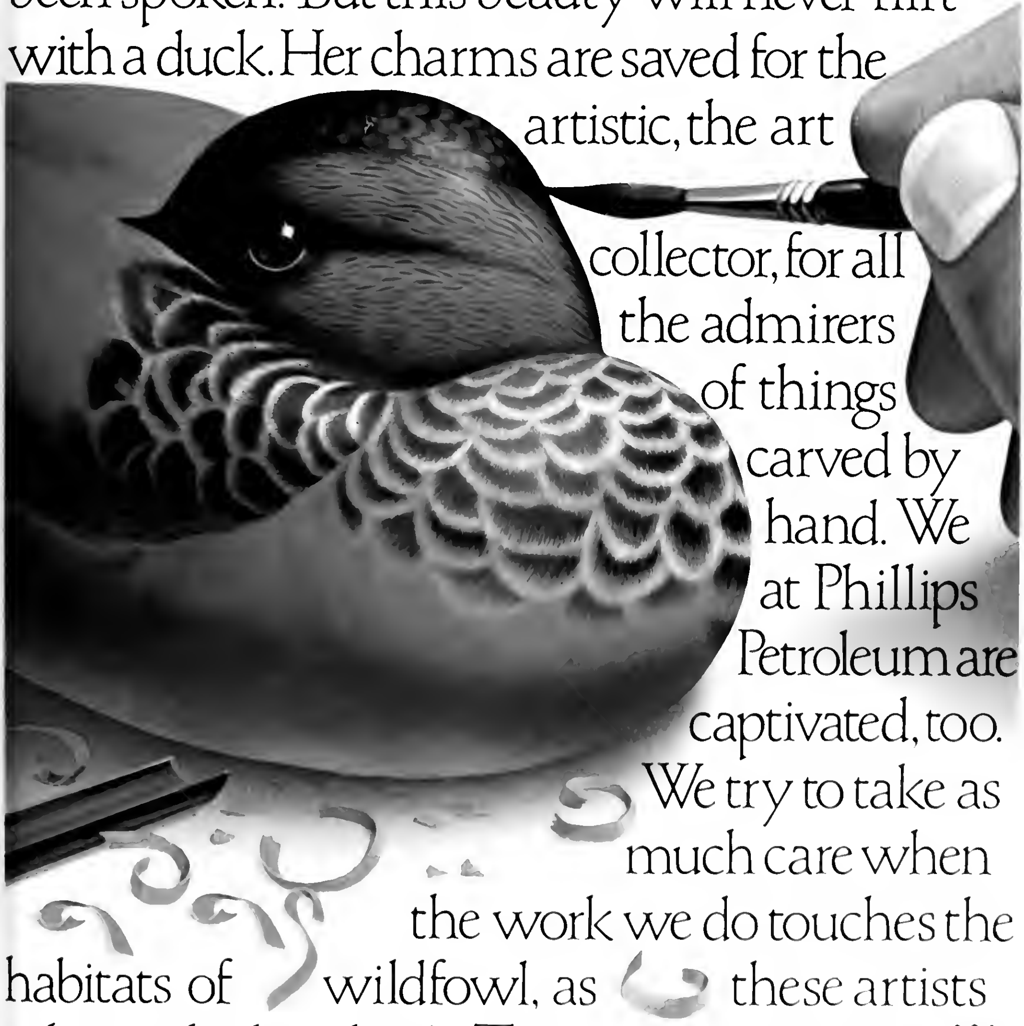

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Cover: *Most ancestral primates were probably active at night, so the study of such nocturnal species as the lesser bush baby can shed light on the evolution of primate behavior. Photograph by Jan and Des Bartlett, Bruce Coleman. Story on page 76.*

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There is only one real pioneer. It's Sony.

1957: The world's first pocket transistor radio.

In 1954, a fledgling Japanese tape recorder manufacturer visited America to investigate a new device called the transistor.

At first, things were less than encouraging.

"Transistors are only good for hearing aids," they were told. "And besides, they can't be mass produced."

Undeterred, the Japanese representatives returned to Tokyo.

Thirty-six months later, the world saw its first pocket transistor radio.

1954: The first Japanese transistor.

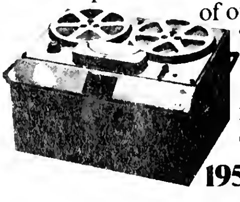
Followed by the world's first all-transistor FM radio.

And, partially as a sign of their continuing dedication to audio, the Tokyo Telecommunications Engineering Corporation adapted the Latin word for sound—"sonus"—and changed its name to Sony.

In the years that have followed, Sony has never faltered in its dedication to technological innovation. And we'd be loathe to estimate how often our advances have ended up on the circuit boards and front panels of our competitors' equipment as "technological breakthroughs."

But enough of the past.

The hi-fi components featured here stand as eloquent proof that Sony—the company that virtually founded the era of transis torized high fidelity—is still at its very forefront.



1950: Japan's first tape recorder, the "Type G."

A few Sony Audio firsts:

- **1949:** Obtained patent on the basic magnetic tape-recording system.
- **1952:** Developed stereo broadcasting in Japan.
- **1954:** Introduced condenser microphone.
- **1955:** First consumer stereo tape recorder in Japan.
- **1959:** Invented "Tunnel Diode"; basis of all high-speed, low-distortion semiconductors.
- **1965:** First all-silicon solid state amplifier.
- **1966:** The first servo-controlled turntable. Forerunner of quartz-locked turntables.
- **1968:** First electronic end of record sensor.
- **1969:** First digital-synthesized FM tuner.
- **1969:** Invented the ferrite tape head.
- **1973:** Invented the V-FET: Opened era of high-speed transistors.
- **1973:** First to manufacture ferrichrome tape.
- **1973:** Dr. Esaki wins Nobel Prize in Physics for "Tunnel Diode."
- **1975:** First turntable with carbon-fiber tone arm.
- **1977:** The world's first consumer digital audio processor.
- **1977:** First consumer amplifier with pulse power supply.
- **1978:** Patented liquid crystal recording meters.

The V5 receiver: To this day, only Sony offers Sony quality

Unlike hi-fi receivers designed to impress you with a facade of magic buttons and switches, Sony receivers are designed to impress you with rich sound.

Case in point: the V5.

In technical terms, the V5 delivers 85 watts per channel a 8 ohms from 20 to 20,000 hert with no more than 0.07% total harmonic distortion.

In human terms, this mea the receiver can reproduce eve note of music any instrument can play with no audible distortion. And it can power two s of speakers without straining.

But that's only the beginning.

Instead of using the mundane power transformers foun in competitors' products, the V utilizes more expensive toroid core transformers that provide richer bass.

1979: The V5 receiver: Designed for people who appreciate value as much as they appreciate sound.

in high fidelity.

1979: The new TA-F40 integrated amplifier and ST-J60 digital synthesized FM tuner. Separate components that sound as sophisticated as they look.

Instead of cutting corners by using a flimsy pressboard bottom, we've cut interference by encasing the *entire* receiver in metal.

And for better FM reception, instead of using the standard three- or four-gang variable-tuning capacitor, we've opted for a higher quality five-gang model.

All of which explains why if you pay a few dollars less for one of our competitors' receivers, it's probably because you're getting less receiver.

The new Sony cassette decks: The state of the art, from the people who invented it.

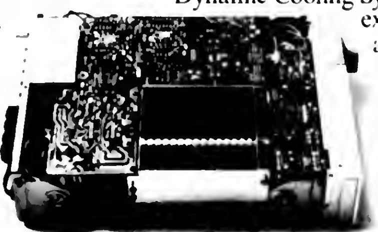
1979: The new TC-K65. Sony remains one of the only hi-fi companies to produce our own tape transports, motors, meters, heads—even the tape itself.

Since we introduced tape recording to Japan in 1950, Sony has sold millions of tape decks.

A quick look at our new TC-K65 cassette deck will explain why.

Like all two-motor cassette decks, the TC-K65 is designed for low wow and flutter. Unlike others, however, we feature "brushless and slotless" motors that reduce this problem to the point of being inaudible.

Instead of using just any tape head material, the TC-K65 features Sony "Sendust and Ferrite" heads that combine wide response with extreme durability.



1979: The Sony "ThermoDynamic Cooling System." Until now, only available in satellites.

Instead of using an ordinary metering system, we've developed a 16-segment LED meter whose life expectancy far exceeds the fancy blue fluorescent models other companies are currently touting.

And there's also a "Random Music Sensor" for preprogramming tapes, settings for metal tape, remote control and timer capabilities, and the kind of high-quality D.C. tape head amplifier you'll find in almost no one else's tape decks.

But you really haven't heard anything yet.

Unfortunately, we don't have enough space here to tell you the complete Sony hi-fi story.

Like the way a recent dealer survey rated our turntables #1 in value and performance.

Or the way our new separate tuners and amplifiers (not to mention micro components) utilize highly advanced light-weight pulse power supplies whose levels of distortion are virtually unmeasurable.

Or how they use a NASA developed "Thermo-Dynamic Cooling System" that eliminates heat, excess wire and the distortion and interference that normally accompany them.

If you'd like to hear more about the complete line of Sony hi-fi components (or if you need the name of your nearest dealer) write to Sony, P.O. Box CN 04050, Trenton, New Jersey 08650.

In the meantime, if somebody makes noise about innovations in high fidelity, think of the biggest pioneer in audio. And remember Sony.

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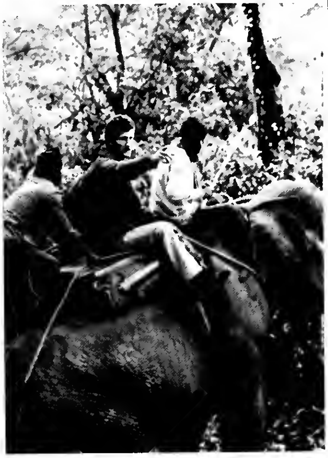
Authors

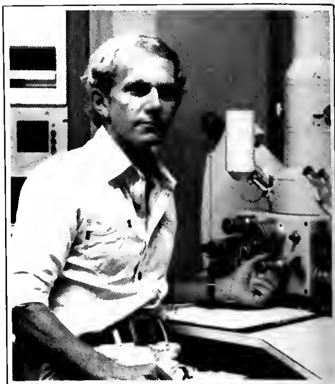
The Pakhtun people are eager to be generous and kind toward guests, but their households are torn by strife. This contrast struck **Charles** and **Cherry Lindholm** when they were doing fieldwork in the Swat Valley of Pakistan. Living there as a family with their twelve-year-old daughter, the authors were able to get close to Pakhtun domestic life and were allowed for the first time to take photographs inside the purdah households of Swat. Charles Lindholm, who received his Ph.D. in cultural anthropology from Columbia University, is a lecturer at Barnard College. He is also a graphic artist and has published some fiction. Cherry Lindholm, born in Hull, England, has a master's degree in psychology from Columbia University Teachers College. She is a part-time researcher and free-lance writer and photographer.

Since receiving his Ph.D. from Michigan State University in 1978, **Dietrich Schaaf** has been a free-lance environmental consultant. His work on barasingha, or swamp deer, was done from 1974 to 1976 on the Royal Sukla Phanta Wildlife preserve in southwestern Nepal. Schaaf writes that seven months after the project began, his fiancée joined him and "we were married in Katmandu, about 300 miles as the crow flies from our work area. We lived in the field in a small thatched house on stilts, which I built with help from local villagers. We often depended on a rented domestic elephant for transport and fieldwork, especially during the monsoon rains." At this point, Schaaf's prime research interest is the ecology and behavior of ungulates and birds.



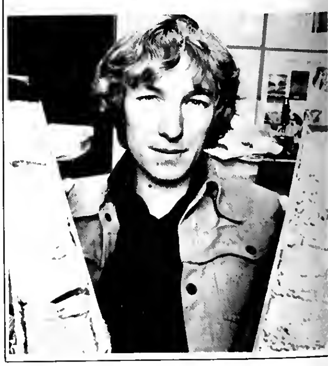
When a swarm of wasps drove prospective customers away from a Georgia condominium development, entomologist **Robert W. Matthews** was called in to help. The experience sparked his interest in yellow jackets and eventually led to his unraveling the ecological tale of why the queens of some species often fight to the death. A professor of entomology at the University of Georgia, Matthews has done fieldwork in the Americas and Australia.

Coauthor with her husband of a textbook, *Insect Behavior*, **Janice R. Matthews** collaborates with him in researching parasitic, solitary, and social wasps. She is a free-lance science writer and part-time student. Between the two of them, they enjoy a variety of activities: beekeeping, gardening, home brewing, and raising bantam chickens, tropical fish, and four children.



Born in Iceland and educated in Ireland and England, **Haraldur Sigurdsson** has settled in the United States. Since 1974 he has been associate professor at the Graduate School of Oceanography at the University of Rhode Island. A specialist in volcanology, Sigurdsson has done fieldwork for thirteen years in his native country, as well as on the Greek island of Santorini and in the Lesser Antilles. One of his future research projects is the examination of deep-sea drill cores from the North Atlantic to learn about explosive volcanism in that region during the past 50 million years.

British coauthor **Stephen Sparks** spent two years at the University of Rhode Island Graduate School of Oceanography as a NATO research fellow and has since taken up the post of lecturer in geology at Cambridge University in England. Their article in this issue is the second time the team of Sparks and Sigurdsson has written for *Natural History* (see "The Big Blast at Santorini," April 1978).



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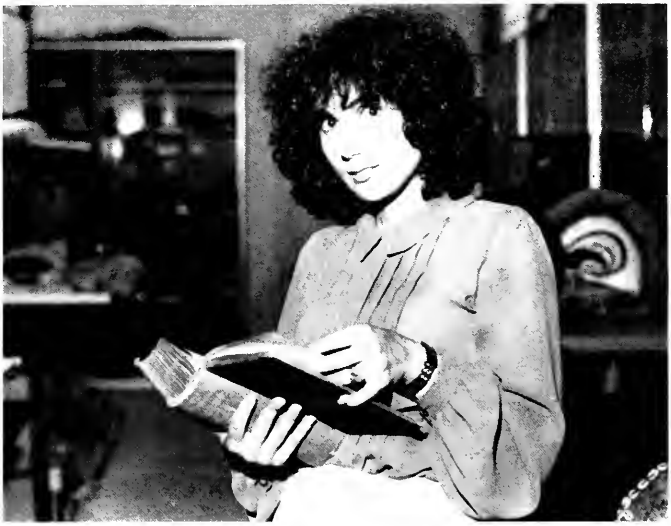

The ancient deities must have noticed that an exhibit of Huichol art was in preparation at the Fine Arts Museums of San Francisco—how else to explain the timely arrival of Mariano Valadez, a Huichol Indian who could guide the effort to assemble the exhibit. The story of the collaboration that followed is related by **Kathleen Berrin**, the museum's associate curator of Africa, Oceania, and the Americas. Berrin is interested in what members of native populations think and feel about their own art. She has focused as well on "activating the art museum experience"—using computers and manipulative games to provide information to museum visitors and to assess their aesthetic responses to exhibits. A graduate student in cultural anthropology at the University of Washington, Berrin plans to do fieldwork in Melanesia for her doctoral dissertation.

Primate evolution has been the research focus for **Robert D. Martin** since 1964, when he began his postdoctoral work with Niko Tinbergen and Konrad Lorenz. A number of field studies in Madagascar and South Africa followed, with Martin concentrating on the behavior and ecology of such prosimians as lemurs and bush babies. At present he is investigating the methods used in reconstructing the evolutionary relationships of primates. Possibly his most ambitious project is a long-term study of the behavioral ecology of different primate species in a given ecosystem, with a hard look at the energy flows involved. "Radio Bush Baby" is his third article on primates for *Natural History*. When at home in London, where he is a reader in physical anthropology at University College, Martin enthusiastically pursues a mediocre squash game.

Coauthor **Simon K. Bearder** began doing fieldwork on the lesser bush baby in 1968. His study area was "Mosdene," a farm in the northern Transvaal and the site of his later collaboration with Martin on this nocturnal prosimian. Bearder has also studied the thick-tailed bush baby in the northeast Transvaal; Zululand; and Umtali, Rhodesia. Two years were given to researching the feeding habits and social behavior of spotted hyenas. A research fellow at the Wellcome Laboratories of the Zoological Society of London, he took up an appointment in September as lecturer in physical anthropology at the Oxford Polytechnic.

Cuvier, a small island off the northeast coast of New Zealand, is the site of the recovery of a bird that is slowly flapping its way upward from near extinction. On a research trip there, **Philip Zeigler**, in cooperation with the New Zealand Wildlife Service, helped band more than thirty saddlebacks, and otherwise chart the species' comeback and its remarkable behavioral ecology. A professor of psychology at Hunter College and a research associate in the Department of Animal Behavior at the American Museum of Natural History, Zeigler is occupied with learning the ways in which birds and mammals eat and drink. He has done much work on the way the brain controls feeding behavior in pigeons.

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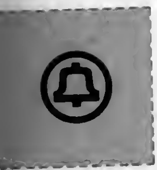

D

A

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– remove center holes from wheels B & C

Now...

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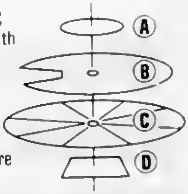
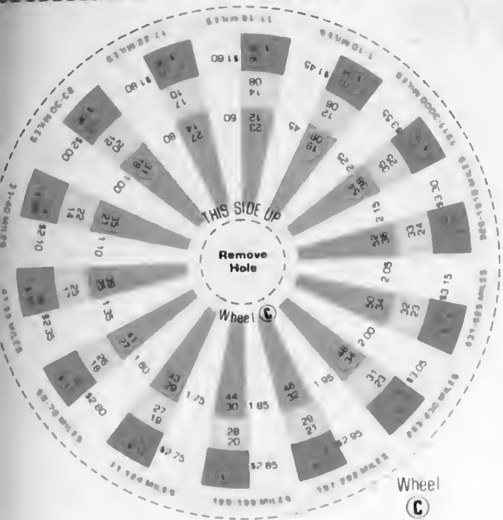
3. Place wheel B over wheel C with center holes in line with each other
4. Moisten adhesive on small round piece A press and rub firmly over center hole of wheel B; let dry for 10 seconds before turning wheel





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Marriage as Warfare

For a Pakhtun, whose home is a battlefield, friendship is only a fantasy

by Charles Lindholm and Cherry Lindholm

The rapid beating of the war drums reverberates along the narrow winding streets of a Pakhtun village, isolated in the remote mountain valley of Swat in northwestern Pakistan. However, it is not a battle that the drums are heralding. It is a marriage.

The Yusufzai Pakhtun of Swat are members of the great Pakhtun (or Pathan) tribe, which dominates Afghanistan and northern Pakistan. They have long been famous for their aggressive daring and bravery in warfare, their fiery pride and individualism, and their refusal to accept defeat or domination. Historically, they have always been the conquerors, never the conquered.

The nomadic Yusufzai migrated to the fertile valley of Swat from Kabul in the early sixteenth century. After defeating the local population and reducing them to landless servants, the Yusufzai settled down and became small farmers (any Yusufzai Pakhtun who lost his land joined the despised servant class and was stripped of his rights and his honor as a Pakhtun). In the nineteenth century the Swat Pakhtun won the admiration of the British for their successful resistance to colonial invasion, and they acceded to Pakistan only when assured of local autonomy. Even today, the valley of Swat is relatively free from the influence of the state, and order is maintained by personal strength and the force of custom.

Swat's climate is suitable for double cropping (wheat and clover in the spring, rice and corn in the fall), and the sparkling Swat River, which bisects the valley, provides an adequate water supply. There is an extensive irrigation system, and the hillsides are well terraced. But despite the lush appearance of the valley, overpopulation has placed a terrible strain on the resource base, and competition for control of land is fierce and sometimes deadly. Innumerable bloody battles have been waged since the Yusufzai established their rule in Swat.

Inside her house, a girl of twelve, hearing the war drums' energetic tattoo, cowers in fear on a string cot. She cries silently behind the folds of her voluminous embroidered shawl, while her relatives gather about her, their faces long and mournful. Even the bright luster of the girl's golden jewelry does little to alleviate the atmosphere of tension and distress in the household.

The girl on the cot is the new bride, and she and her family are waiting for the moment when she must leave her natal home forever and take up residence in her husband's house. The use of the war drums for a wedding is actually far from ludicrous, for marriage in Swat is very much like a prolonged combat and is recognized as such by both men and women. The relationship resembles that between two opposing countries where an ever present cold war frequently erupts into skirmishes and open conflict.

During our nine-month stay in a Swat village in 1977, we witnessed such relationships firsthand. With our twelve-year-old daughter, we lived with a Pakhtun family in three small rooms that had been constructed on the roof of their house. As friends, guests, and adopted relatives, we were accepted into the life of the village with the warmhearted generosity and hospitality for which the Pakhtun are deservedly renowned.

This remarkable hospitality, combined with an idealized notion of male friendship, is one of the three cornerstones of *Pakhtunwali*, the Pakhtun code of honor, the other two being refuge and blood revenge. This code is older than Islam and often supersedes Islamic tenets. For example, Islam allows divorce, *Pakhtunwali* does not; also, sometimes a man will swear falsely, his hand on the Holy Koran, in order to save a friend.

Although the Pakhtun are strict Sunni Muslims, they derive their identity and self-respect from the zealous observance of *Pakhtunwali*, land ownership, and tight control over women by means of a rigorous system of purdah (female seclusion). The worst insult one can offer a man is to call him *begherata*, man without honor. This pejorative has three meanings: someone who is lazy and weak, someone who has lost his land, and someone who has no control over his women. To the proud Pakhtun, loss of honor is worse than death, since it renders him unworthy of the name "Pakhtun."

The Pakhtun's liberal hospitality is generally demonstrated on the stage of the *hujera*, or men's house, where the guest is enthusiastically welcomed, made comfortable on a cot with fat cushions behind his head, served tea and the best food available, and showered with his proud host's unstinting attentions. To entertain a guest is a great honor, and the host will spare no effort to make the occasion as lavish and enjoyable as possible. Nor is this ritualized hospitality mere etiquette or a means of swelling the host's self-esteem. The warm friendliness that accompanies the ritual is genuine, deeply felt, and extremely moving. In the *hu*

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jera, the violent Pakhtun of the battlefield, who will fight to the death for his land, for someone else's land, or to avenge any slight on his honor, becomes the epitome of cordiality, gentle dignity, and brotherly affection.

This metamorphosis is not altogether surprising. In a society where survival depends upon a man's physical and psychological toughness, there is little chance to express such emotions as affection and tenderness. The guest in the *hujera* fulfills in ritual fashion the role of the idealized friend who, according to one Pakhtun proverb, "without invitation, will assure me of his love." This dream of the perfect friend, always a man, which has been honored in countless proverbs and poems over the centuries, is the beloved fantasy of every Pakhtun male. The friend, however, must necessarily be a stranger, for all Swat Pakhtun are, by the very nature of their harsh and competitive society, rivals and potential enemies. Naturally, given these qualifications, friendship in Swat is very rare indeed. Yet the dream persists and is acted out in the rite of hospitality whenever the opportunity arises.

In sharp contrast to the romantic image of the friend and public display of hospitality, the Pakhtun's domestic arena, concealed behind the impenetrable walls of the purdah household, is the site of confrontations more akin to those of the battlefield.

As the drumming grows louder, the trembling bride remembers her mother's advice for a successful marriage: "You must keep power over your husband. Always speak first when he enters, even if only to cough. Sleep with your hand behind his head. Then

photographs by Cherry Lindholm

In a Swat village, a palanquin transports a bride to her new home

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he will miss you and never be satisfied with any other."

The girl prays that her husband will like her and that he will not humiliate her and her family by taking a second wife. That would be the worst possible catastrophe. She is of a good family and her family pride is strong.

Now the time has come for her to leave. She clutches at the cot, but her elder brother pulls her hands free and lifts her onto the palanquin that will carry her to her husband's house. The embroidered cover is dropped into place, and the girl is carried into the narrow street. Men of the husband's house are waiting to join the procession. They help with the palanquin and triumphantly bounce it about. Village boys line the route and throw stones, hoping to overturn the bride into the muddy alley. In the past, serious fights sometimes erupted because of injuries caused by this ritual stoning, but in recent years the violence has lessened.

The procession continues through the village, led by the men carrying the bride and followed by a supply of household goods from her father's house. The drums of the groom are now heard as the procession approaches his compound. Men of his family gleefully fire their rifles, and small boys toss sweets to the crowd from the low rooftops. The drumming reaches a crescendo as the party enters the groom's house. This is a tense moment. Sometimes, the groom's family tries to deny entry to the men of the bride's party, and a fight breaks out. But today everything goes smoothly, and men of both houses carry the palanquin into the inner courtyard.

Strong hands lift the bride onto a cot in the corner of the single room where she will live with her husband. The men then leave the house to begin feasting in the *hujera*. Totally enclosed in her shawl, the new bride presses tightly to her chest the Koran her father has given her. The women of the household surround her, talking incessantly and cajoling her to show her face. A young girl begins the drumbeat for women, and the groom's female relatives start dancing in the courtyard, celebrating the newcomer's arrival. Later, they will give her money, and in return, she will bow before them and touch their feet in token of future subservience. But, for the moment, the bride remains motionless on the cot. She will stay in this position for three days, rising only to relieve herself. On the third night her husband will creep into the house to consummate the marriage.

While the bride huddles nervously in her new home, the groom, a green-eyed man of twenty-five, is fingering his mustache in the *hujera* of a relative, a different *hujera* from the one where the feasting is taking place. He is not permitted to join in the festivities of the marriage but must hide in shame at losing his bachelor status. Twenty years ago, young grooms sometimes ran away from their home villages and had to be coaxed back to their wives. But men's shame is no longer so acute. In those days, all men slept in the *hujera* and only slipped out to visit their wives secretly at night. Women also were shyer then, and a man might not see his wife's face for a year or more. But nowadays, with the curtailment of warfare and the weakening of the village khans, or leaders, most men sleep at home with their wives.

The groom is speculating about his new wife's appearance. He has never seen her, but he has heard reports that she is light skinned and fat—an ideal beauty. His own sexual experience has been with boys his own age who played the passive role and with girls of the servant class. For him, sexual dominance is an expression of power. He hopes that the youth and innocence of his bride will render her docile and respectful. However, he fears that the marriage will be a contentious one. That is how all marriages end up. "It is because our women are no good," he muses.

For two more nights the groom stays in the *hujera*, pretending indifference to his marriage. Then, on the third night, he steals into his family's compound and opens the door of the room where his bride is waiting. He is slightly inebriated from smoking hashish. She is unveiled and afraid to look at him. Sometimes, the groom finds his bride repulsive and cannot have sex with her. Or he may have been enchanted by a male lover and rendered incapable of heterosexual intercourse. The bride has no recourse, for Pakhtun marriage is a lifetime contract. Moreover, the wife even follows her husband to heaven or hell, so that they are united for eternity.

In the room adjoining the nuptial chamber, the groom's sisters have bored a hole in the wall and are spying on the couple. The groom gives the girl a gold watch and some sweets. He begins to caress and tease her, but she is too terrified to respond, and the sexual act is rough and hasty. Thus the couple enter into married life.

The giving of a woman in marriage is a touchy business for the Swat Pakhtun. Historically, a weak lineage gave women to its stronger neighbors in order to form alliances, and victors in war expressed their triumph by taking women from the conquered. As a result, there is the suggestion that the wife givers are inferior to the wife takers—and any hint of inferiority is intolerable to a Pakhtun. Hostility toward marriage as an institution is seen in the ritual stoning of the bride's palanquin and in the fights between the bride's party and the groom's party. If divorce were allowed, no marriage would last for long.

The groom feels shame at his marriage because every Pakhtun man, not

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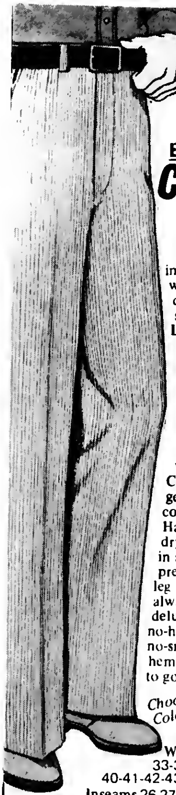

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unlike the mythical American cowboy, seeks to present himself as completely self-reliant, independent, and free of obligation. But the cowboy can always reject home and family and ride away into the sunset—an option the Pakhtun man does not have. Instead, he effectively hides his wife inside the privacy of the purdah household. Her presence is known to an outsider only through the tea she prepares. The Pakhtun woman must never be seen by men who are not close family members. She must never leave the compound walls without her husband's permission. By remaining a virtual prisoner inside her husband's house, she helps to uphold his honor, for she is a part of all he possesses and her behavior is a direct reflection of his power and control..

Years ago, if a Pakhtun woman was seen by a man who was not her relative, her enraged husband would cut off her nose as a punishment and as a means of cleansing his family honor, which her carelessness had sullied. While this custom has been abandoned, severe beatings are common. And a woman found alone with a man who is not a relative has committed a killing offense, for it will be assumed that the liaison is sexual. In such a case, although the husband may not actually desire her death, the pressure of public opinion, the code of *Pakhtunwali*, which demands vengeance, and his own sense of acute shame, would all push him to take action.

Because they are able to dishonor men, women are feared. On the other hand, the woman has only physical violence to fear from her husband. Even more than the male, she is accustomed to violence from childhood. Her personal pride is far more powerful than her fear of a beating. Although she is a prisoner in her husband's house, her position is in some ways stronger than his, for she holds the weaponry for his dishonoring, whereas he holds merely a stick with which to beat her. While the wife must live with her jailer, the husband is obliged to share his house with an enemy—and an extremely tenacious and able one.

Marriage thus begins as a hostile relationship. The young bride's apprehension and the groom's shame accompany the determination of each to dominate the other. Pakhtun marriage demands a precarious balance of power, and the young partners are ready from the start to fight each other to avoid being dominated and shamed.

It is now a year after the marriage—the bride has her place within her husband's household. In her eyes, she is treated like a slave. Her mother-in-law is impossibly demanding; the girl can do nothing right. Her husband takes no notice of her beyond the servicing of his sexual needs. Recently, she has begun having fits in which she is possessed by demons. During these fits, she rolls in the dirt and must be restrained from throwing herself into the well or the fire. From her mouth, demonic voices hurl abuse at her husband and his family. Exorcisms by a holy man, who puts sticks between her fingers and squeezes her hand painfully, are only temporarily effective. Finally, her father is asked to intervene. "If this happens again," he warns her, "I'll shoot you." The demons stop appearing.

Shortly afterward, she gives birth to a son, and her position in her husband's household improves. She is now respected, for she has contributed to perpetuating her husband's line. But her relations with her mother-in-law continue to be as unpleasant as ever.

As time goes by, the marriage proves to be as difficult as the young groom feared. Fighting goes on daily, over the wife's poorly made milk curd or over a piece of rotten meat the husband has foolishly purchased. The husband may strike out because his wife is nagging him to buy another piece of jewelry that she can show off to her neighbor; the wife may be irate because the husband, in a display of generosity, has depleted the family larder. Anything can cause a serious fight, and several times the bruised wife returns, with injured pride, to her father's house. There she is pampered by her relatives for a time, but she must go back to her husband upon his demand. She returns, and the fights continue.

Like all Pakhtun husbands, he severely beats his wife to break her of bad habits and make her submissive. The young woman nonetheless remains proud and fearless; far from becoming meek, she defends herself aggressively, clawing at her husband's face and tearing the shirt from his back. He strikes out, especially at her face, and sometimes uses a club or throws a stone at her. This is considered perfectly normal, and the wife is even somewhat proud of her battle scars. She abuses her elder sister's husband, who rarely hits his wife, as "a man with no penis." Yet her own husband fares no better, as she frequently calls curses down upon him and abuses his

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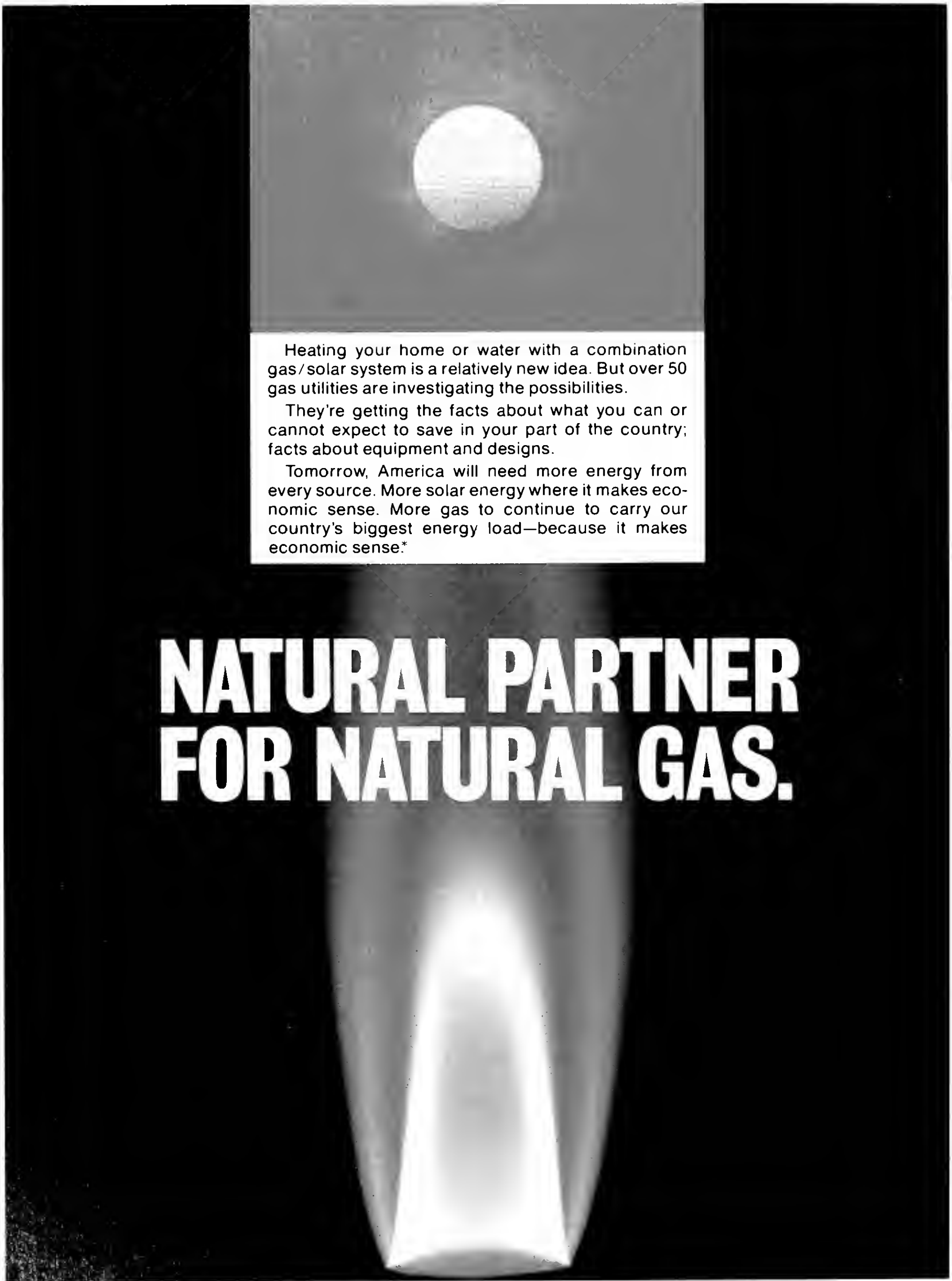

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lineage: "Your ancestor was nothing and my ancestor was great!"

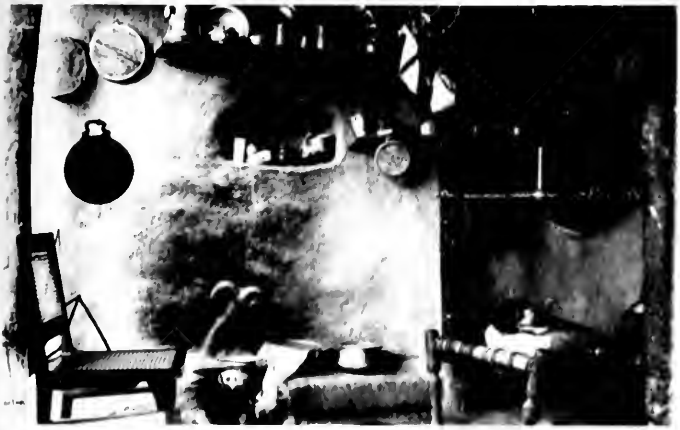
The husband, becoming wearied with the constant effort to subdue and control his defiant female adversary, dreams of defeating her once and for all by bringing in another, more tractable wife. He frequently threatens her with this ultimate humiliation, but is unable to implement his plan because he lacks funds. Despite the proverb that "a fool can be recognized by his two wives," most men dream of a second marriage. Those few who can afford it, however, inevitably regret it, for with the arrival of a second wife, warfare begins in earnest. Each woman seeks, with magical spells and sheer contentiousness, to drive the other out. Sometimes, one wife will poison the other or, more commonly, the husband; sometimes the husband's throat is slit while he sleeps. The first wife continually badgers the husband to bring in yet a third wife, in order to humiliate the second wife as she has been humiliated. The besieged husband, who has found the second wife as irritating as the first, futilely wishes he could turn back the clock.

Although they continue to squabble, the husband and wife are actually quite fond of each other. Each admires the other's resolute pride and fighting ability. But the man cannot show his affection, for to do so would give the wife courage to dishonor him. A man who displays affection to his wife is indicating weakness, which the woman will immediately exploit in the battle for domination. She may begin leaving the house without permission, confident that the loving husband will not punish her. Then she will start having affairs with other men, thoroughly dishonoring her weakling spouse. Therefore, a man must avoid laughing with his wife or showing her any tenderness, in spite of his feelings for her. "Instead of a kiss, he gives me a bite," says the wife, baring her teeth. But if he did give her a kiss, she would begin to feel he had become emasculated.

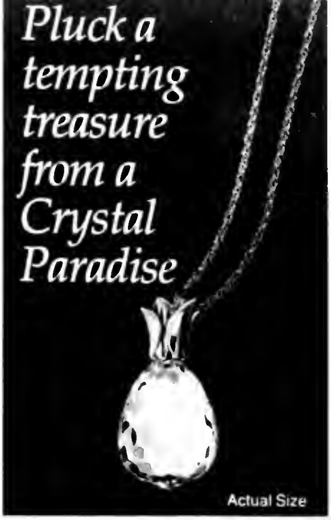
The husband carries his feigned indifference to his wife into public life, never mentioning her to his friends. Nor do they inquire after her; to do so would be a breach of etiquette. Instead, they merely ask him, "How is your house?"

The wife is not so constrained. Confined to the compound, she spends much of her time complaining to visitors, to servants, and even to her children about the activities of her husband. Gossip about the wrongdoings of their men is the major subject of women's conversations. "All Swat men are rotten," they say. That is the nature of men. The wife's solace is hearing the tribulations of other women and anticipating the power she will wield in her later years. By that time, her husband will be a tired old man, without the energy for fighting, her sons will be grown, and their wives will be living in her house under her rule. She will control her domestic sphere like a real matriarch, and the purdah compound, her former prison, will become her court. Indeed, the Western image of the docile purdah female is an inaccurate picture of the Pakhtun woman of Swat.

This story is representative of the marriage relations among the Yusufzai



Cooking area in the purdah compound: "The woman's place is in the house or in the grave," say the Pakhtun



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Pakhtun. Perhaps a particular couple will fight less than usual because of extraordinary meekness or compatibility. Fortunate couples may reach a sort of wary, joking understanding in old age. But, in general, the marriage relation is one of strife, violence, and struggle.

This pattern of hostility and rivalry derives from the social model of the society, which is technically termed a segmentary lineage system. This means that the Yusufzai Pakhtun trace themselves, through the male line, to a common ancestor, Yusuf, the progenitor of the entire clan. All consider themselves equal, and all have rights in the family land. Despite this ideology of equality, however, those who are strong force the weak from their land. To be a landless Pakhtun is to lose one's birthright and become a member of the servant class. Thus, each family seeks to protect itself and subordinate others.

Life in the Yusufzai village is largely a contest to determine dominance. A man's chief rival is his father's brother's son, who has a claim on the land of the common grandfather. This cousin is often one's in-law as well, since marriage with the father's brother's daughter is greatly favored in Swat. By marrying their female patrilineal cousin, the Yusufzai hope to gain control over their main political rival, but to no avail, since such marriages are notoriously hostile.

The term for the father's brother's son is *tarbur*, a word that means enemy. But the *tarbur* is also an ally, for only he can be counted upon to come to one's aid in case of an attack by a more genealogically distant adversary. Groupings occur on the basis of patrilineal kinship and only take place when there is an external threat. When the British attacked them, the Yusufzai Pakhtun forgot their internal enmities and united to expel the invader.

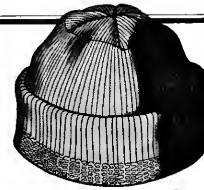
In this system, men constantly maneuver for power and honor. Loyalties shift easily. As one family becomes strong, others unite against it. Some families rise, but are soon torn apart by internal dissension. As the modern Pakhtun writer Ghani Khan has observed, "The Pakhtun have not become a great nation because a man would rather burn his house than see his elder brother rule it."

In such an environment, a martial air and genuine willingness to fight are absolute necessities for survival. Even hospitality, the most loving relationship found in the society, is tinged with rivalry, as hosts express their strength and dominance through lavish entertainment. The assertion of one's own pride and the denigration of other lineages is therefore the primary emotional stance of the Pakhtun. This stance is not confined to men. The women also consider all men not of their patrilineage to be of inferior quality. Every marriage is thus with an inferior, and the partners are well prepared to fight each other to uphold the honor of their respective houses.

Although the husband tries to ignore his wife, she refuses to be overlooked. Her own pride, instilled by her lineage, demands that she assert herself. The woman's place is in the house, however—patrilineal descent prevents her from inheriting land or from participating in struggles over land. Where a man's pride and identity rest in his landholdings, her honor is found in vindicating her superiority in the household. The bruises that inevitably result she regards as marks of honor. If her health is good, if she can avoid being expelled by another wife, and if she has sons, her struggle is likely to end in victory. The aging husband, beset by rivals on all sides, and even besieged by his own sons demanding their share of his land, will accept his wife's rule in exchange for relative peace in the compound.

Small wonder that the Pakhtun man dreams of the mythical friend. This dream, and the ritual of hospitality in which it finds expression, derives from the stern social order, which sets every man against every other, and which prevents any amicable relationship within the family. Deprived of any real opportunity to be affectionate and generous, the Pakhtun male releases these suppressed feelings in the rite of hospitality.

Women, on the other hand, have no great interest in hospitality, although they cook for guests for the sake of their own pride. Unlike the man, who seeks to dominate in a world of opponents, the woman strives only to dominate in the house. The man's goal is impossible, but the woman's is fairly attainable. Women are also united in a community of complaint against their husbands. They do not engage in life and death struggles over land, and in consequence, their enmities are less deep than the men's. Despite the travails and bruises of marriage, women tend to succeed in their goals, while men spend their time pursuing a chimera of friendship. □



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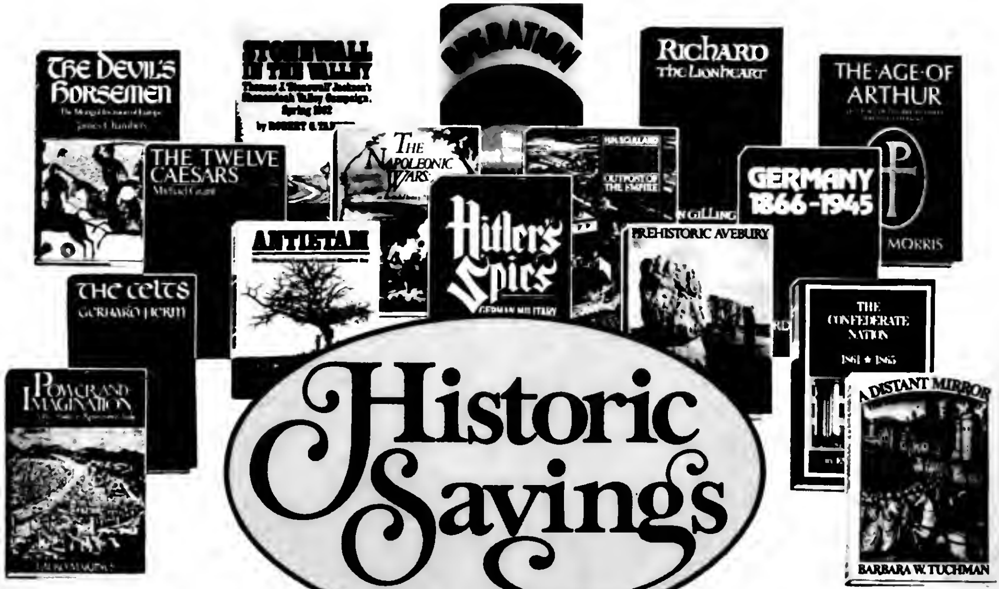

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Shades of Lamarck

Lamarckian evolution helps explain "our current, maddening acceleration toward something new and liberating—or toward the abyss"

The world, unfortunately, rarely matches our hopes and consistently refuses to behave in a reasonable manner. The psalmist did not distinguish himself as an acute observer when he wrote: "I have been young, and now am old; yet have I not seen the righteous forsaken, nor his seed begging bread." The tyranny of what seems reasonable often impedes science. Who before Einstein would have believed that the mass and aging of an object could be affected by its velocity near the speed of light?

Since the living world is a product of evolution, why not suppose that it arose in the simplest and most direct way? Why not argue that organisms improve themselves by their own efforts and pass these advantages to their offspring in the form of altered genes—a process that has long been called, in technical parlance, the "inheritance of acquired characters." This idea appeals to common sense not only for its simplicity but perhaps even more for its happy implication that evolution travels an inherently progressive path, propelled by the hard work of organisms themselves. But, just as we all must die, and just as we do not inhabit the central body of a restricted universe, so the inheritance of acquired characters represents another human hope scorned by nature.

The inheritance of acquired characters usually goes by the shorter, although historically inaccurate, name of Lamarckism. Jean Baptiste Lamarck (1744–1829), the great French biologist and early evolutionist, believed in the inheritance of acquired characters, but it was not the centerpiece of his evolutionary theory and was certainly not original with him. Entire volumes have been written to trace its pre-Lamarckian pedigree. Lamarck argued that life is generated, continuously and spontaneously, in very simple form. It then climbs a ladder of complexity, motivated by a "force that tends incessantly to complicate organization." This force operates through the creative response of organisms to "felt needs." But life cannot be organized as a ladder because the upward path is often diverted by requirements of local environments; thus, giraffes acquire long necks and wading birds webbed feet, while moles and cave fishes lose their eyes. Inheritance of acquired characters does play an important part in this scheme, but not the central role. It is the mechanism for assuring that offspring benefit from their parents' efforts, but it does not propel evolution up the ladder.

In the late nineteenth century, many evolutionists sought an alternative to Darwin's theory of natural selection. They reread Lamarck, cast aside the guts of it (continuous generation and complicating forces), and elevated one aspect of the mechanics—inheritance of acquired characters—to a central focus it never had for Lamarck himself. Moreover, many of these self-styled "neo-Lamarckians" abandoned Lamarck's cardinal idea that evolution is an active, creative response by organisms to their felt needs. They preserved the inheritance of acquired characters but viewed the acquisitions as direct impositions by impressing environments upon passive organisms.

Although I will bow to contemporary usage and define Lamarckism as the notion that organisms evolve by acquiring adaptive characters and passing them on to offspring in the form of altered genetic information, I do wish to record how poorly this name honors a very fine scientist who died just 150 years ago. Subtlety and richness are so

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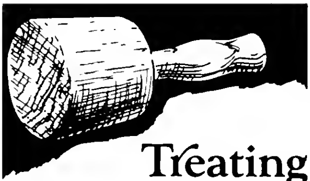

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often degraded in our world. Marx felt compelled to deny that he was a Marxist. And consider the poor marshmallow—the plant, that is. Its roots once made a fine candy; now its name adheres to that miserable ersatz of sugar, gelatine, and corn syrup.

Lamarckism, in this sense, remained a popular evolutionary theory well into our century. Darwin won the battle for evolution as a fact, but his own theory for its mechanism—natural selection—did not win wide popularity until the traditions of natural history and Mendelian genetics were fused during the 1930s. Moreover, Darwin himself did not deny Lamarckism, although he regarded it as subsidiary to natural selection as an evolutionary mechanism. As late as 1938, for example, Harvard paleontologist Percy Raymond, writing (I suspect) at the very desk I am now using, said of his colleagues: "Probably most are Lamarckians of some shade; to the uncharitable critic it might seem that many out-Lamarck Lamarck." We must recognize the continuing influence of Lamarckism in order to understand much social theory of the time—ideas that become incomprehensible if forced into the Darwinian framework we often assume for them. When reformers spoke of the "taint" of poverty, alcoholism, or criminality, they usually thought in quite literal terms—the sins of the father would extend in hard heredity far beyond the third generation. When Lysenko began to advocate Lamarckian cures for the ills of Soviet agriculture during the 1930s, he had not resuscitated a bit of early nineteenth-century nonsense, but a still respectable, if fast fading, theory. Although this tidbit of historical information does not make his hegemony, or the methods he used to retain it, any less appalling, it does render the tale a bit less mysterious. His debate with the Russian Mendelians was, at the outset, a legitimate scientific argument. Later, he held on through fraud, deception, manipulation, and murder—that is the tragedy.

Darwin's theory of natural selection is more complex than Lamarckism because it requires *two* separate processes, rather than a single force. Both theories are rooted in the concept of *adaptation*—the idea that organisms respond to changing environments by evolving a form, function, or behavior better suited to these new circumstances. Thus, in both theories, information from the environment must be transmitted to organisms. In Lamarckism, the transmission is direct. An organism perceives the environmental change, responds in the "right" way, and passes its appropriate reaction directly to its offspring.

Darwinism, on the other hand, is a two-step process, with different forces responsible for variation and direction. Darwinians speak of genetic variation, the first step, as "random." This is an unfortunate term because we do not mean random in the mathematical sense of equally likely in all directions. We simply mean that variation occurs with no preferred orientation in adaptive directions. If temperatures are dropping and a hairier coat would aid survival, genetic variation for greater hairiness does not begin to arise with increased frequency. Selection, the second step, works upon *unoriented* variation and changes a population by conferring greater reproductive success upon advantageous variants.

This is the essential difference between Lamarckism and Darwinism—for Lamarckism is, fundamentally, a theory of *directed* variation. If hairy coats are better, animals perceive the need, grow them, and pass the potential to offspring. Thus, variation is directed automatically toward adaptation and no second force, such as natural selection, is needed. Many people do not understand the essential role of directed variation in Lamarckism. They often argue: isn't Lamarckism true because environment does influence heredity—chemical and radioactive mutagens increase the mutation rate and enlarge a population's pool of genetic variation. This mechanism increases the *amount* of variation but does not propel it in favored directions. Lamarckism holds that genetic variation originates *preferentially* in adaptive directions.

In the June 2, 1979, issue of *Lancet*, the leading British medical journal, for example, Dr. Paul E. M. Fine argues for what he calls "Lamarckism" by discussing a variety of biochemical paths for the inheritance of acquired, but *nondirected*, genetic variation. Viruses, essentially naked bits of DNA, may insert themselves into the genetic material of a bacterium and be passed along to offspring as part of the bacterial chromosome. An enzyme called "reverse transcriptase" can mediate the reading of information from cellular RNA "back" into nuclear DNA. The old idea of a single, irreversible flow of information from nu-

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clear DNA through intermediary RNA to proteins that build the body does not hold in all cases—even though Watson himself had once sanctified it as the "central dogma" of molecular biology: DNA makes RNA makes protein. Since an inserted virus is an "acquired character" that can be passed along to offspring, Fine argues that Lamarckism holds in some cases. But Fine has misunderstood the Lamarckian requirement that characters be acquired for adaptive reasons—for Lamarckism is a theory of directed variation. I have heard no evidence that any of these biochemical mechanisms leads to the preferential incorporation of *favorable* genetic information. Perhaps this is possible; perhaps it even happens. If so, it would be an exciting new development, and truly Lamarckian.

But so far, we have found nothing in the workings of Mendelism or in the biochemistry of DNA to encourage a belief that environments or acquired adaptations can direct sex cells to mutate in specific directions. How could colder weather "tell" the chromosomes of a sperm or egg to produce mutations for longer hair? How could Pete Rose transfer hustle to his gametes? It would be nice. It would be simple. It would propel evolution at much faster rates than Darwinian processes allow. But it is not nature's way, so far as we know.

Yet Lamarckism holds on, at least in popular imagination, and we must ask why? Arthur Koestler, in particular, has vigorously defended it in several books, including *The Case of the Midwife Toad*, a full-length attempt to vindicate the Austrian Lamarckian Paul Kammerer, who shot himself in 1926 (although largely for other reasons) after the discovery that his prize specimen had been doctored by an injection of India ink. Koestler hopes to establish at least a "mini-Lamarckianism" to prick the orthodoxy of what he views as a heartless and mechanistic Darwinism. I think that Lamarckism retains its appeal for two major reasons.

First, a few phenomena of evolution do appear, superficially, to suggest Lamarckian explanations. Usually, the Lamarckian appeal arises from a misconception of Darwinism. It is often and truly stated, for example, that many genetic adaptations must be preceded by a shift in behavior without genetic foundation. In a classic and recent case, several species of tits learned to pry the tops off English milk bottles and drink the cream within. One can well imagine a subsequent evolution of bill shape to make the pilferage easier (although it will probably by nipped in the bud by paper cartons and a cessation of home delivery). Is this not Lamarckian in the sense that an active, nongenetic behavioral innovation sets the stage for reinforcing evolution? Doesn't Darwinism think of environment as a refining fire and organisms as passive entities before it?

But Darwinism is not a mechanistic theory of environmental determinism. It does not view organisms as billiard balls, buffeted about by a shaping environment. These examples of behavioral innovation are thoroughly Darwinian—yet we praise Lamarck for emphasizing so strongly the active role of organisms as creators of their environment. The tits, in learning to invade milk bottles, established new selective pressures by altering their own environment. Bills of a different shape would now be favored by natural selection. The new environment does not provoke the tits to manufacture genetic variation directed toward the favored shape. This, and only this, would be Lamarckian.

Another phenomenon, passing under a variety of names, including the "Baldwin effect" and "genetic assimilation," seems more Lamarckian in character but fits just as well into a Darwinian perspective. To choose the classic illustration: Ostriches have callosities on their legs where they often kneel on hard ground, but the callosities develop within the egg, before they can be used. Does this not require a Lamarckian scenario: Ancestors without callosities began to kneel and developed them as a nongenetic adaptation acquired during life, just as we, depending on our profession, grow writer's calluses or thickened soles. These callosities were then inherited as genetic adaptations, now forming well before their use.

The Darwinian explanation for "genetic assimilation" can be illustrated with the midwife toad of Paul Kammerer, Koestler's favorite example—for Kammerer, ironically, performed a Darwinian experiment without recognizing it. This terrestrial toad descended from aquatic ancestors that develop roughened ridges on their forefeet—the nuptial pads. Males use these pads to hold the female while mating in their slippery environment. Midwife toads, copulating on *terra firma*, have lost the pads, although a

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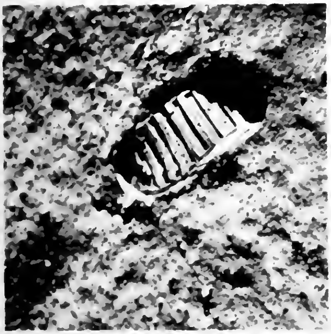

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few odd individuals do develop them in rudimentary form—indicating that the genetic capacity for producing them has not been entirely lost.

Kammerer forced some midwife toads to breed in water and raised the next generation from the few eggs that had survived in this inhospitable environment. After repeating the process for several generations, Kammerer produced males with nuptial pads (even though one later received an injection of India ink, perhaps not by Kammerer, to heighten the effect). Kammerer concluded that he had demonstrated a Lamarckian effect: he had returned the midwife toad to its ancestral environment; it had reacquired an ancestral adaptation and passed it on in genetic form to offspring.

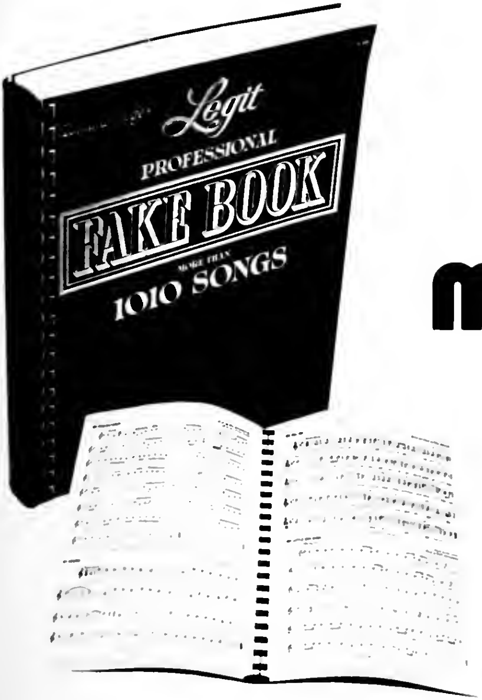
But Kammerer had really performed a Darwinian experiment: when he forced the toads to breed in water, only a few eggs survived. Kammerer had exerted a strong selection pressure for whatever genetic variation encourages success in water. And he reinforced this pressure over several generations. Kammerer's selection had gathered together the genes that favor aquatic life—a combination that no parent of the first generation possessed. Since nuptial pads are an aquatic adaptation, their expression must be tied to the set of genes that confer success in water—a set enhanced in frequency by Kammerer's Darwinian selection. Likewise, the ostrich may develop callosities first as a nongenetic adaptation. But the habit of kneeling, reinforced by these callosities, also sets up new selective pressures for the preservation of random genetic variation that may also code for these features. The callosities themselves are not mysteriously transferred by inheritance of acquired characters from adult to juvenile.

Secondly, and I suspect more importantly, Lamarckism seems to offer some comfort against a universe devoid of intrinsic meaning for our lives. It reinforces two of our deepest prejudices—our belief that effort should be rewarded and our hope for an inherently purposeful and progressive world. Its appeal for Koestler and other humanists lies more in this solace than in any technical argument about heredity. Darwinism offers no such consolation for it holds only that organisms adapt to local environments by struggling to increase their own reproductive success. Darwinism compels us to seek meaning elsewhere—and isn't this what art, music, literature, ethical theory, personal struggle, and Koestlerian humanism are all about. Why make demands of nature and try to restrict her ways when the answers (even if they are personal and not absolute) lie within ourselves.

Thus Lamarckism, so far as we can judge, is false in the domain it has always occupied—as a biological theory of genetic inheritance. Yet, by analogy only, it is the mode of "inheritance" for another and very different kind of "evolution"—human cultural evolution. *Homo sapiens* arose at least 50,000 years ago, and we have not a shred of evidence for any genetic improvement since then. I suspect that the average Cro-Magnon, properly trained, could have handled computers with the best of us (for what it's worth, they had slightly larger brains than we do). All that we have accomplished, for better or for worse, is a result of cultural evolution. And we have done it at rates unmatched by orders of magnitude in all the previous history of life. Geologists cannot measure a few hundred or a few thousand years in the context of our planet's history. Yet, in this millimicrosecond, we have transformed the surface of our planet through the influence of one unaltered biological invention—self-consciousness. From perhaps one hundred thousand people with axes to more than four billion people with bombs, rocket ships, cities, televisions, and computers—and all without substantial genetic change.

Cultural evolution has progressed at rates that Darwinian processes cannot begin to approach. Darwinian evolution continues in *Homo sapiens*, but at rates so slow that it no longer has much impact on our history. This crux in the earth's history has been reached because Lamarckian processes have finally been unleashed upon it. Human cultural evolution, in strong opposition to our biological history, is Lamarckian in character. What we learn in one generation, we transmit directly by teaching and writing. Acquired characters are inherited in technology and culture. Lamarckian evolution is rapid and accumulative. It explains the cardinal difference between our past, purely biological mode of change, and our current, maddening acceleration toward something new and liberating—or toward the abyss.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.



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by Andrea K. Dupree and Lee Hartmann

Hunting for Black Holes

Evidence for the existence of these exotic objects mounts but is necessarily indirect

The search for black holes is one of the most interesting and publicized topics of current astronomy. These bizarre objects, predicted as a natural consequence of Einstein's theory of general relativity, may be responsible for such diverse behavior as X-ray emission from some binary stars, exceptionally strong gravitational pull toward the centers of globular clusters, and varieties of energetic activity in the nuclei of many galaxies. However, the evidence for black holes is generally very indirect, with the possible exception of one X-ray binary star—Cygnus X-1. The effort to find compelling evidence for the existence of black holes is therefore likely to occupy astronomers for some time to come.

Shortly after the equations of general relativity were published by Einstein in 1916, Karl Schwarzschild, a German physicist, pointed out that their solution for the gravitational effects around a very compact mass had a mathematical "singularity." Theoretically, objects falling into this singularity would disappear from the universe. Even light cannot escape from a singularity because of its intense gravitational forces, hence the name, black hole. Much odd behavior has been hypothesized for black holes, including the suggestion that an infalling object could "pop" out into another universe; however, that is speculation for it is not at all clear whether such an effect could actually occur.

Let us imagine what would happen as a black hole is approached. An object falling into a black hole would move faster and faster, until it was moving almost at the speed of light. Seen from the outside, the object would take forever to fall in because of the slowdown of time. It would also eventually be impossible to see the object any longer since light from it would be shifted from the visible toward the red region of the electromagnetic spectrum by the pull of gravity. An observer riding on the object would see things differently. The fall would take a finite rather than an infinite amount of time. Light rays from the outside world could get to the observer but, after passing through the surface of the black hole, the observer could never communicate with the outside.

How is a black hole made? Extreme compression of matter is required. And we need to realize that the force of gravity is inversely proportional to the square of the distance between two attracting masses. Thus, by reducing an object to a size vastly smaller than that of its normal state, the force of gravity on its surface can be increased so much that other nearby objects could not escape from it. Even particles traveling away from it at the speed of light—the greatest speed that any particle can achieve—could not escape from it. The earth would have to be compressed into a ball less than an inch across for this to happen; the sun, with a radius of forty billion miles, would need to be compressed to a radius of about one mile. Evidently, drastic events are required to make a black hole.

For years, black holes remained a mathematical curiosity. Then in 1939 J. Robert Oppenheimer and his student Hartland Snyder realized that black holes might result from the collapse of a sufficiently massive star. Hence, there was a real possibility that these

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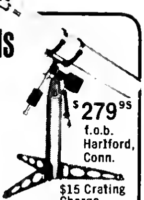

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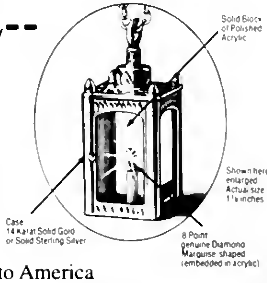

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objects could actually come from the natural course of astronomical events. The obvious place to search for such objects was among the luminous stars. But there is a problem with black holes; they cannot be seen because they are, well, black, or almost black. (In remarkable and important new work the English astrophysicist Stephen Hawking has recently shown that black holes actually *do* radiate and will ultimately disappear, converting all of their mass to radiated energy. However, this radiated power is negligibly small for black hole masses as heavy as those of stars, and these are the only black hole masses expected to come from the evolution of astronomical objects in our present universe.)

The only way massive black holes can be detected is by their influence on neighboring objects. This realization led two Soviet astronomers in the early 1960s to examine binary stars in which one of the stars was unseen and the motion of the visible star revealed properties of its unseen companion. Their hope was that one of these dim companions might be a black hole. No conclusion was reached, despite their efforts and those of other astronomers. But a powerful new technique, X-ray observation, later became available to facilitate the search.

Observations made after the advent of space-based X-ray astronomy in the late 1960s and early 1970s showed that most of the galactic X-ray sources were binary stars, with one member unseen in visible light. It was quickly recognized that the unseen companions must be high-gravity stars. These dense stars wrench gas from their normal companion stars, and because of the high gravity involved, the gas is accelerated to very high speeds. These gas streams become heated and emit X-rays as they fall on the surface of a dense star or crash into other streams of accreted material.

It may be possible to detect black holes if they are members of X-ray binaries. The problem is that there are two other kinds of stars, white dwarfs and neutron stars, that also have sufficiently high surface gravities to produce hot, X-ray-emitting gas. Thus the search for black holes has become in part an effort to distinguish them from other compact stars.

Dense stars are the remnants of much heavier stars whose lives have ended. Because of self-gravity, stars would collapse inward were it not for the light and heat they generate at their centers; this energy creates an outward pressure that balances the gravitational forces. When stars run out of their nuclear fuel, gravity is no longer balanced and collapse occurs. Most stars, such as our sun, will collapse until they become white dwarfs, their material compacting until it is a million times denser than that of the earth, and the matter resists further collapse.

If the star is a little more massive than the sun, the gravity is sufficiently strong to force negatively charged electrons to combine with positively charged protons, making the matter almost all neutrons, which, as the name suggests, carry no charge. Since normal matter is mostly empty space, with electrons orbiting the nuclear protons and neutrons at very large distances, the elimination of the orbiting electrons means that the matter can be greatly compressed.

A star with a core of up to about three solar masses becomes a neutron star, with a final diameter of about ten miles. For a stellar core of three or more solar masses, the force of gravity cannot be resisted by the matter and the core collapses into a black hole. This scenario, obtained from careful calculations of very compressed matter, indicates that the basic way to distinguish black holes from other compact stars is by mass.

In general, the masses of objects held in orbit about each other by gravity can be determined by observing their orbits. Unfortunately, in the systems that have likely candidates for black hole companions, the orbit of the compact object cannot be observed directly. In order to estimate the mass of the compact star, it is necessary to observe the orbit of the primary star, and then make assumptions about the orientation of the orbit in space and infer the mass of the primary star from its color and luminosity. These problems can make mass estimation difficult.

The most likely example of a black hole is found in the binary X-ray source Cygnus X-1, already mentioned. The best estimates at present suggest that the mass of the compact object in Cygnus X-1 is at least nine solar masses. This result is not completely certain, and alternatives have been suggested, such as having a third, faint star in the system; triple stars are known to exist. Nevertheless, the case for a black hole in Cygnus X-1 appears plausible at this time.

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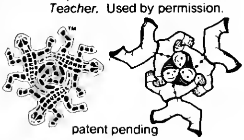

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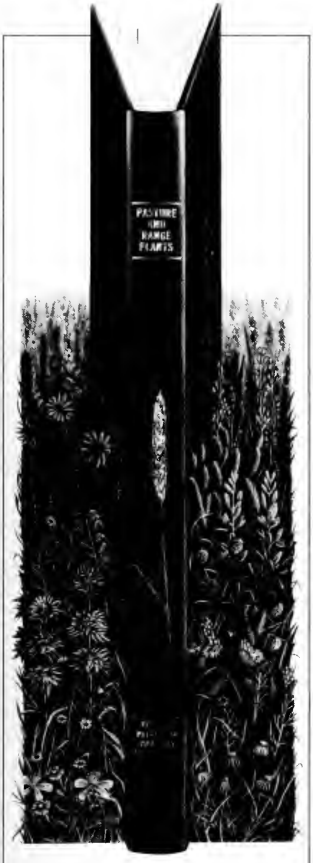

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one might distinguish other compact objects from black holes. For example, isolated, rapidly spinning neutron stars are generally pulsars, identified by the regular, periodic bursts of energy they emit. There may similarly be identifying marks that would enable us to single out black holes. However, the accretion of gas into compact objects is not well understood, so that it is not yet possible to distinguish black holes by this effect. Further studies of the X-ray emission are needed if this method is ever to work. In this regard, the new X-ray satellite launched in November, the Einstein Observatory, is of vast importance; because of its greater sensitivity, many new X-ray sources will be discovered, enhancing our understanding of the overall problem of X-ray emission.

Important information about X-ray sources can also be obtained from observations in spectral regions other than X-rays. At the Center for Astrophysics, we and our colleagues have been studying X-ray sources with the newly launched International Ultraviolet Explorer (IUE) satellite. By observing very faint sources, this satellite has enabled astronomers to probe more deeply into the ultraviolet region of the spectrum. The ultraviolet region is uniquely rich in emissions from ion species formed at the high temperatures expected in outer stellar atmospheres. We have been studying the ultraviolet signatures of X-ray sources such as Cygnus X-1 as part of a collaboration with other American, British, and European astronomers. These observations show details of the gas motions and temperatures in X-ray systems that are not obtainable from X-ray data. The interpretation of these data has just begun, but they undoubtedly contain important clues about the nature of the X-ray emission process.

For example, the appearance of the spectrum of the Cygnus X-1 binary varies as the two stars move around their orbit. This variation is due to the effects of the X-rays on the primary, normal star. An analysis of this data will yield information about the emission of the presumed black hole.

We have also observed Vela X-1, which has a primary star very similar to that of the Cygnus X-1 system. The compact object in Vela is a pulsar, however, so we know that it is a neutron star. We will be looking carefully at a comparison of Cygnus X-1 and Vela X-1 to see if they exhibit different behavior.

Turning away from binary stars, the case for black holes becomes much less certain, although more spectacular. The discovery of X-ray sources near the centers of some globular clusters generated a great deal of excitement, particularly when it was found that the X-ray clusters had very bright, condensed nuclei, composed of many closely congregated stars. A strongly gravitating object seemed to be pulling the stars inward. Observers hypothesized that a central, massive black hole could account for both the X-ray emission as well as the clustering of stars.

A globular cluster is a gravitationally bound group of stars, usually numbering a few hundred thousand, distributed in a volume a few tens of light-years across. At the center of an X-ray cluster, the stellar distribution is particularly dense, with stars separated by only one-hundredth the average distance between stars in the solar neighborhood. The density of stars is so great that they may actually collide, an unthinkable prospect elsewhere in our galaxy (except perhaps at the galactic center). If the solar system were transported to the center of such a cluster, it would be likely that sometime during its life, the sun would form a binary system with another star, which could disrupt the planetary orbits (or incinerate the planets if the new star happened to be a red giant).

For a black hole to be able to influence stars over distances of light-years, it has to be very massive, nearly a thousand times the mass of the sun. Such an object could not result from stellar evolution, as normal stars are not bigger than about one hundred solar masses. It might be possible that such black holes collapsed at the beginning of the universe, under very different conditions, or that stars falling into the center of a globular cluster might coalesce into something much bigger, although recent calculations shed doubt on the effectiveness of this process.

In any event, the central black hole would have to be very massive, not only to attract the neighboring stars but also to pull in and accrete the gas floating through the cluster to produce the recorded X-rays. This gas, shed by other stars as they evolve, has been searched for by many observers without success. Perhaps the missing gas can be collected into an unobservably small volume at the cluster's center.

However, there are alternatives to the black hole model—the collapse of massive stars. One is as follows: The

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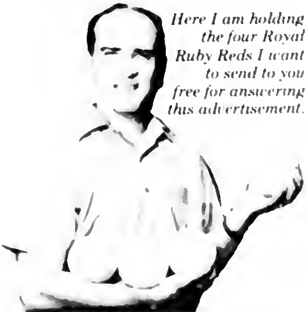

Here I am holding the four Royal Ruby Reds I want to send to you free for answering this advertisement.

You decide whether or not Royal Ruby Reds are everything I say. You determine whether or not eating a Royal Ruby Red is the fantastic taste experience I promise.

You decide. I'm confident that you and your family will want more of this superb fruit - and on a regular basis, too. If the four Royal Ruby Reds make you say "yes," then keep the remaining fruit. Otherwise return the unused fruit (at my expense) and you won't owe me a single penny.

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This way you are sure to receive your package containing 16 or 20 Royal Ruby Reds for you and your family to sample a few days before Christmas. But since the supply is strictly limited it's important to place your order now.

SEND NO MONEY NOW

I'll put the bill for $11.98 for this first shipment on the top of the box. That's a saving of $5.00 off the regular price of $16.98. All delivery charges are prepaid by me. Remit only after my Ruby Reds have proved themselves, otherwise you don't owe a thing.

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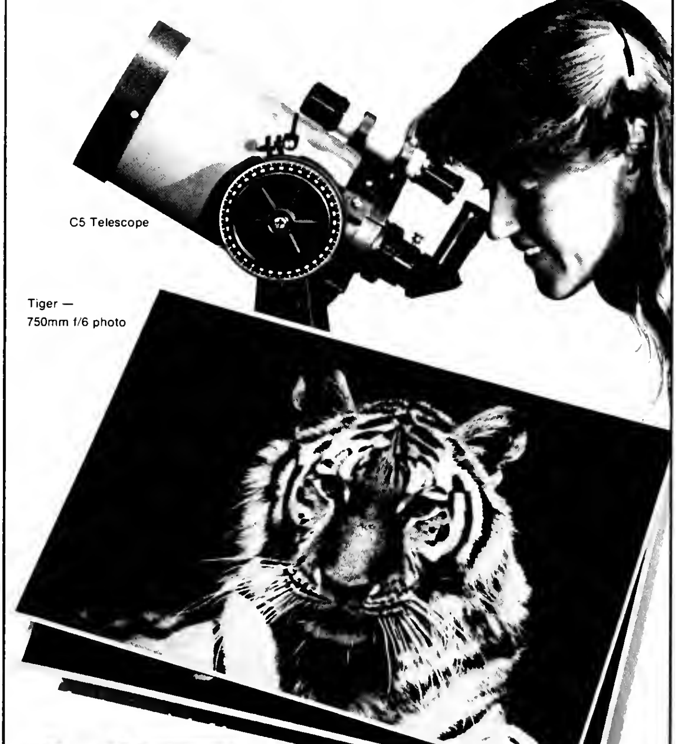

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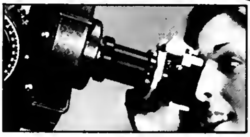

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stellar densities are so high that gravitational interactions among the cluster stars are important. Energy can be transferred to more distant stars, resulting in a shrinking of the cluster core. If the core shrinks enough, it can collapse gravitationally, producing a dense cluster core without an initial central massive object.

Astronomers proposing this explanation suggest that the globular cluster X-ray sources are binaries like other known galactic sources. Any binary system present in the cluster will act in many ways like a single object with a mass equal to the sum of the two components. In the evolution of a cluster, heavy stars sink to the center while less massive stars tend to be propelled farther out. The binaries, being heavier than average stars, will eventually concentrate at the center, and one of them might be an X-ray source. Or, because stars can be captured at the very dense center, X-ray binaries might be "captured." Thus it appears possible to explain the globular cluster nuclei without invoking a central black hole.

(As an example of how rapidly theories become outdated in this area, recent work by scientists with the Einstein Observatory has shown that some globular cluster X-ray sources are near, but not exactly at, the clusters' centers: this may rule out central, massive black holes, at least for producing the X-ray emission.)

Our group at the Center for Astrophysics has also been studying the cores of globular clusters with the IUE satellite. The ultraviolet data show the tightly bound cores of stars expected to be present in the X-ray clusters we have observed. In most cases we see only the hottest stars in the cluster, which radiate most strongly at ultraviolet wavelengths. However, one X-ray globular cluster, NGC 6624, is not expected to have any hot stars. Our observations of this cluster show that there is a faint, hot object present at its exact center. There is a strong presumption that this hot object is the X-ray source, which is hidden at longer wavelengths (that is, visible light) by the multitude of cool stars present near the cluster center.

The X-ray binaries we have observed with the IUE satellite have definite ultraviolet signatures, caused by the X-ray emission of the compact object. By comparing the source in NGC 6624 with our other X-ray binaries, we should be able to see if the cluster object defines a new class of X-ray source

or whether it is similar to other galactic X-ray binaries. Unfortunately, the central object is very faint, making it difficult to determine the exact nature of the object's spectrum. In the near future we should obtain a great deal more data on NGC 6624, from which we may be able to make definite statements about the nature of the central object.

Observers have also found a bright nucleus in the galaxy M87, which might be the result of a large congregation of stars orbiting a very massive black hole. Similar kinds of cores have been suggested for the nuclei of other galaxies. Many astronomers have suggested that the accretion of matter by extremely massive black holes could be the energy source of active galactic nuclei and quasars. The likelihood is, however, that we will understand the nature of black hole candidates closer to home—within our own galaxy—much sooner than we will resolve questions about the nature of these very distant, extremely energetic objects.

Andrea K. Dupree is senior research associate at the Harvard College Observatory. Lee Hartmann is a research physicist at the Harvard-Smithsonian Center for Astrophysics.

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An Active Submarine Volcano

"Kick'em-Jenny," in the Lesser Antilles volcanic arc, is growing larger year by year and may someday emerge above sea level as an island

by Haraldur Sigurdsson and Stephen Sparks

On 24 September 1952, the Japanese oceanographic research vessel *Kaiyo-maru* and its entire crew of twenty-nine vanished into the swirling waters above the Myozin-syo submarine volcano some 230 miles south of Tokyo. The ship was investigating a week-old eruption of the volcano, and it is believed that the vessel must have been directly above the volcano's submarine vent, or crater, when a catastrophic explosive eruption occurred. Ships sent to search for the *Kaiyo-maru* recovered only wreckage, with pieces of volcanic rock fragments embedded in the wood.

Myozin-syo is one of a string of volcanoes that make up the Izu-Bonin volcanic arc of the western Pacific. Several of these volcanoes have grown from the sea floor to form islands above sea level, while others remain entirely submerged. Volcanic arcs of this type are a characteristic feature of the Pacific Ocean and create a nearly unbroken "ring of fire" around this ocean basin.

In the Atlantic Ocean the active Lesser Antilles volcanic arc, a semicircle of "fire," stretches about 450 miles from the island of Grenada in the south to the island of Saba in the north. This submarine mountain chain, an elongate volcanic barrier separating the Caribbean Sea from the Atlantic Ocean, is built almost entirely of volcanic rocks with the major peaks emerging above sea level.

Many tourists in this region are familiar with the volcanoes above sea level such as Martinique's notorious Mount Pelée, which took 28,000 lives in a 1902 eruption, and La Soufrière on Saint Vincent, which last erupted in April 1979. But very few are aware of a submarine volcano known as Kick'em-Jenny, the most active volcano in the arc, whose documented eruptions have occurred every third year over the past sixteen years.

We have been studying Kick'em-Jenny since 1972, monitoring its growth and evolution during oceanographic cruises in the Caribbean region. This volcano provides a rare opportunity to follow the growth process of an undersea mountain from the sea floor to its ultimate emergence as a new island—expected in the near future.

(The etymology of Kick'em-Jenny is a mystery. Ever since the Grenadians discovered an active volcano on their doorstep, they have called it Kick'em-Jenny. Formerly, however, the name was applied to a nearby pinnacle, now more aptly named Diamond. Some claim that local sailors used the name to describe ripping currents in the region.)

Kick'em-Jenny is five nautical miles north of the tropical spice island of Grenada, in the midst of the schooner and sailboat route through the Grenadines to Saint George's harbor in Grenada. No one knew what lurked under the tranquil waters there until July 24, 1939, when a black column of volcanic ash and steam—accompanied by explosions and earthquakes—rose almost 1,000 feet out of a boiling sea.

Explosive eruptions are catastrophic events by any standard. Underwater explosions can be triggered by the ejection of molten rock, or magma, from the crater into the overlying ocean. The interaction of the red-hot magma, at temperatures of more than 1,000°C, with the seawater causes flash boiling and generates steam. The immediate result is a thousandfold increase in the volume of the water vapor involved. The ensuing explosions are therefore a direct effect of the rapid mixing of seawater and molten hot magma in the crater. Submarine explosions can consequently be much more intense than comparable eruptions on land.

We now know of eight eruptions of Kick'em-Jenny that have taken place since 1939. Only one of these, in 1974, was directly observed on the surface; the others were detected by earthquake-recording devices, or seismographs, located throughout the Caribbean and as far north as Puerto Rico.

Kick'em-Jenny is an actively growing volcano. Five bathymetric, or deep sea, surveys carried out at the site show a systematic increase in the altitude of this approximately 4,250-foot-high undersea mountain. In 1962 the crater rim was 750 feet below sea level, but by April 1978 the crater was at a 525-foot depth. It had grown eighty feet since 1976. A growth curve constructed from the bathymetric data shows a stepwise height increase that coincides with the main volcanic eruptions as new material has been added to the crater rim and the volcanic cone.

The present evidence indicates a mean growth rate of fifteen feet per year, which could result in Kick'em-Jenny's emergence as a new volcanic island in about 2000. We can, however, only guess at the time of emergence of this new island in the Caribbean, as experience from other regions shows that volcano growth is a fitful


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affair. Thus, in 1963 the submarine volcano Surtsey, in the North Atlantic south of Iceland, grew overnight from a sea-floor depth of 400 feet to above sea level.

New volcanic islands lead a precarious existence once they emerge above sea level, and many islands formed by submarine volcanic action have performed classic disappearing acts, much to the confusion of sailors. In 1783, for example, a Danish vessel discovered a new and active volcanic island, Nyey, on the Mid-Atlantic Ridge southwest of Iceland. The Danish government promptly dispatched a royal expedition to hoist the Danish flag and set up a monumental stone on the island to claim this new territory, but the island could not be found and has never been seen since. Like many other young volcanic islands, its loose volcanic ash and debris broke up and was washed away by the ocean waves.

In 1831 a new volcanic island formed at a depth of 650 feet in the Mediterranean, some 30 miles southwest of Sicily. Known as Graham Island, it rose to a height of 230 feet above sea level, but two years later it too had vanished under the impact of persistent wave action. The island of Surtsey was saved from a similar fate in 1964, when molten lava started to flow over it, thus forming a massive protective armor of solid rock.

Active volcanoes grow by the extrusion of new material from their craters, or vents. We first located the Kick'em-Jenny crater in 1972 at latitude 12°17.96′ north and longitude 61° 38.25′ west, some 625 feet below sea level. The crater was then a bowl-shaped depression, 600 feet wide and 65 feet deep, in the volcano's summit. From that time onward we have taken every opportunity to visit Kick'em-Jenny in the course of later oceanographic expeditions in the region, attracted by the continuing evolution of this mysterious undersea mountain. The first of these surveys was carried out on board the British hydrographic research vessel H.M.S. *Hecla* in 1972, when the topography and general features of Kick'em-Jenny were surveyed in detail.

The volcanic cone, found to be made up of material strikingly different from the sediments on the adjacent sea floor, was shown to be nestling up against the steep western flank of the Lesser Antilles island arc. We lowered spring-loaded grabs to the bottom in a number of areas around the volcano. On touching the sea floor, a grab snaps shut, sealing a bucket-sized sample of the bottom sediment, which is then hauled to the surface for study. Down to depths of 4,250 feet, Kick'em-Jenny's cone turned out to be composed entirely of coarse, black volcanic sand and fist-sized lava blocks. In contrast, the flat sea floor surrounding the volcanic cone was covered by pale-colored calcareous mud. The freshness of the volcanic sand and the lack of a mud sediment blanket on the cone were clear indications of the youth of this volcano.

In May 1976, we returned again to Kick'em-Jenny, anxious to see what changes might have been caused by the major eruption of September 1974. This time we were aboard the University of Miami oceanographic ship R/V *Gilliss*. As soon as we arrived at a position exactly above the crater, we launched a temperature probe from the ship to determine the water temperature on the crater floor, some 650 feet below us. The probe transmitted a continuous record of water temperature as it sank toward the crater below. All eyes were now on the chart recorder, as the probe descended through the 80.6°F surface waters and began its recording of the depths. The temperature of the water column above the crater turned out to be normal for this water depth, gradually decreasing from 77° at a depth of 200 feet to about 55.4° immediately above the crater at a depth of 600 feet. But the record suddenly jumped from 55.2° to 64°, and we knew we had probed a hot spring near the crater floor.

A second probe was launched into the crater to verify these findings. Again the probe recorded a rise in temperature, from 56.1° to 65.1° near the crater floor. These results indicate that large volumes of seawater circulate through the porous volcanic cone, become heated on contact with hot volcanic rock at depths within the volcano, and rise to the surface in the crater.

On our return to Kick'em-Jenny in April 1978, aboard the University of Rhode Island's oceanographic ship R/V *Endeavor*, we found the volcano much changed. Its formerly bowl-shaped crater was now distorted by a major protuberance of lava on its northern rim in the form of a steep hump eighty feet above the old crater rim. The 1977 eruption had clearly made a sizable addition to the volcano. Again the probes recorded elevated

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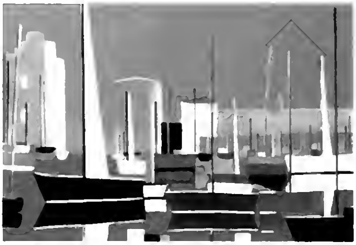

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temperatures of bottom water in the crater. Next we lowered a steel rock dredge over the *Endeavor*'s stern into the crater in an attempt to recover samples of the new lava.

Dredging for volcanic rocks is, without doubt, the crudest ocean-bottom sampling method employed by oceanographers. When you are lucky, the dredge scoops up loose blocks from steep underwater slopes or scree on the sea floor. On the other hand, the dredge may "bite," that is, become snagged on solid rock, thus anchoring the ship. We were unlucky and had a tense tug of war with the sea floor as we gradually pulled in with the ship's deep-sea winch on the five-eighth inch steel cable holding the dredge, hoping to ease it loose before the cable broke, and hoping also to tear off and capture a piece of the rock. Having lost a dredge here on the 1976 *Gilliss* cruise, we knew we could expect the worst. We gradually drew up on the cable with the deep-sea winch until the tensiometer registered 16,000-pounds pull, the safety limit of the cable. Suddenly the dredge broke loose. It was rapidly hauled to the surface and within minutes we had 450 pounds of glistening black volcanic rocks in a pile on the afterdeck.

Laboratory investigations of the rocks from Kick'em-Jenny have told us much about the origin of the magma. Mineralogical and chemical analyses show, for example, that the magma is of the alkali basalt type. And the types of minerals present in the magma at the time of eruption indicate that the magma was derived from a depth approximately ten miles below the volcano, or within the lower crust of the earth.

The ultimate source of magmas, or rock melts, in volcanic arcs such as the Lesser Antilles is, however, believed to lie at a much greater depth, probably fifty to sixty miles under the volcanoes. The formation of these magmas has recently been shown to be intimately connected with the destruction of parts of the earth's lithosphere, the thirty-mile thick outermost terrestrial layer characterized by relatively high rigidity. The surface of the earth is now known to be segmented into a number of lithospheric plates; nearly all volcanic and earthquake activity occurs along their boundaries. Processes within the earth result in the large-scale motion of lithospheric plates over the earth's surface, causing divergence or convergence at the plate margins.

Large-scale convergence of two lithospheric plates brings about a collision and the downthrusting of one plate under the other, thereby creating what is known as a subduction zone. Such downthrusting at rates of an inch per year leads to intense earthquake activity along the surface of the subduction zones whenever one lithospheric plate slips over the other. Seismic studies used to help map out the configuration of these subduction zones indicate that they are generally at a slope of 45° to the earth's surface.

The process of underthrusting, or subduction, in some way provides the heat required for the generation of magmas along the earth's volcanic arcs. Exactly how the process works is still unclear, but several competing hypotheses have been put forward. One of these relates the formation of magmas under the arcs to frictional heating as one plate slides over the other, thereby melting the rocks overlying the subduction zone. A second hypothesis attributes the melting to the fluxing effect of water, that is, water

Haraldur Sigurdsson

The bottom of the Kick'em-Jenny crater was last photographed in April 1978, revealing lava blocks measuring ten to twenty-five inches in diameter and fragments from pillow lavas.

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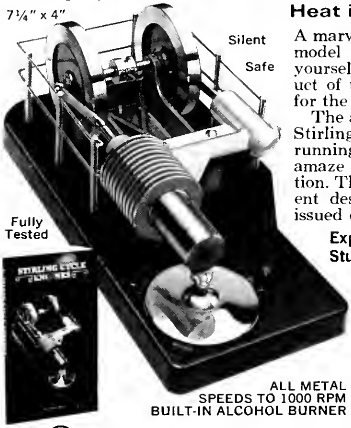

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The emerging submarine volcano Jolnir, near Surtsey, Iceland, erupted in December 1965 and remained active until August 1966. But by December 1966, the island had disappeared.

lowers the melting point of the plate as it descends.

In the Lesser Antilles in 1973 we showed that the subduction zone lies at a depth of fifty to sixty miles under the volcanoes of the arc and that the zone slopes about 40° to 50° to the west. Volcanism in this arc is a direct consequence of the gradual westward drift of the Atlantic lithospheric plate and its thrusting under the Caribbean plate to the west. This process has been operating for 35 million years, resulting in the buildup of the line of volcanic islands in the region.

Our final task before leaving Kick'em-Jenny was to lower an undersea camera from the ship to photograph the sea floor in and around the volcano's crater. The undersea camera was housed in a cumbersome frame, which also contained a strobe light and a sonic device that continuously transmitted the camera's height above the sea floor back to the ship. The field of vision was kept in focus by maintaining the camera frame at a fixed distance of ten feet above the sea floor.

This sounds like a simple procedure, particularly where the sea floor is flat and smooth, but photographing Kick'em-Jenny turned out to be a hair-

Haraldur Sigurdsson

raising affair. How do you keep a camera ten feet off the sea bottom when a strong current causes the ship to drift up to three knots and the bottom is a jagged pile of rocks? Nevertheless, the marine technicians and winch operators on the *Endeavor* managed this feat and obtained excellent close-ups of the crater area. These pictures reveal a jumble of lava blocks, from a few inches to three feet in diameter, piled up in and around the crater, as well as massive pillow-lava flows. From the photographs we infer that recent activity in the crater has been a combination of quiet lava extrusion and explosive eruptions.

As we sailed away from Kick'em-Jenny at the completion of our survey, we could not help but speculate on what lies ahead for this energetic mountain. The likelihood of another eruption before 1980 is very high. Will the volcano then grow to the surface and form a new island in the young republic of Grenada? If so, it will probably closely resemble its 1,000-year-old sister, the extinct volcano of Isle de Caille, four miles to the east. (Isle de Caille is a barren, dry, uninhabited island, covered by black basalt lava flows.)

Further growth of Kick'em-Jenny will, however, make the volcano an increasing hazard to boat traffic in the region. Volcanic eruptions will become more violent and affect a wider area as they occur in ever shallower water. Perhaps an increasing awareness of the dangers below will persuade sailors to steer clear of Kick'em-Jenny and avoid the fate of the Japanese vessel *Kaiyo-maru*.

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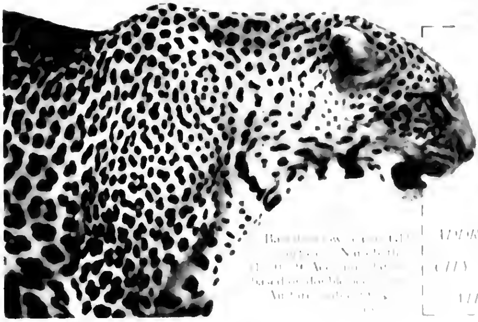

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Swamp Deer in a Human Sea

The clatter of swamp deer antlers can still be heard on a few wildlife reserves in Nepal and India. But people, too, have an urgent need for land

by Dietrich Schaaf

The endangered barasingha, or "swamp deer," once ranged throughout the seasonally wet plains of the great northern India river systems—the Indus, the Ganges, and the Brahmaputra—and roamed as far south as the Godavari River in the state of Madhya Pradesh. The deer reached their greatest abundance on the alluvial grasslands of north India, now the country's most densely populated and highly productive croplands.

Today most of the barasingha live in a half dozen small parks and reserves, totaling about 900 square miles, in India and neighboring Nepal. What little remains of their grassland habitats outside these sanctuaries will no doubt eventually be plowed under. The deer seem to be holding their own, however; their numbers in some of the reserves are increasing, even as the few remaining populations outside the protected areas disappear.

Barasingha are large deer: stags usually weigh between 350 and 400 pounds; hinds are about 100 pounds lighter. Perhaps the heaviest animal on record was a 588-pound stag reported about the turn of the century by the maharajah of Cooch Behar in northeast India.

Barasingha is a Hindi term meaning "twelve horned" and refers to the dozen tines often found on the antlers of mature stags. Although as many as twenty tines, or points, are known from exceptional or malformed antlers, ten to fourteen is the usual range for stags in their prime.

Two subspecies of barasingha are recognized, based on their geographical distribution and on physical differences first mentioned by the British sportsman-naturalist A.A. Dunbar-Brander in his book *Wild Animals in Central India*, published in 1927. Dunbar-Brander noted that deer living in the relatively dry environment of the central Indian highlands have hoofs that are "hard and well knit [like those of animals] accustomed to gallop on hard ground," whereas their northern cousins have splayed, spongy hoofs, the better to support them in their wet habitat on the alluvial plains. Northern deer are also paler and larger than the southern animals, even though the latter carry larger antlers. The largest pair of antlers on record were taken in Madhya Pradesh and measured 41 inches around the outside curves of the main beams.

One of the northern barasingha's last strongholds is the Royal Sukla Phanta Wildlife Reserve, a 57-square-mile tract of forest and grassland on the *terai*, or subtropical lowlands, in the remote southwestern corner of Nepal. That part of the country once was noted for an abundant and varied wildlife, but in recent years much of the forest was cleared and peasant farmers have occupied the land. Few still intact and relatively unexploited areas such as Sukla Phanta remain nowadays.

At one time a hunting preserve for kings and prime ministers, Sukla Phanta was elevated to the status of wildlife reserve in 1976 and became one of eight similar parks and reserves administered by Nepal's recently established Office of National Parks and Wildlife Conservation. Sukla Phanta harbors a number of large animals, several of them rare or endangered species. Tigers and leopards occur there, as do sloth bears and wild boars, the nilgai, or blue bull (a large antelope of the open forests), rhesus macaques and common langurs, and the spotted deer, or chital, hog deer, barking deer, and sambar. The Indian python and marsh crocodile, or mugger, also can be seen by a careful observer. Even a few wild, mature bull elephants remain, but as the land around the reserve is cleared, there will no longer be sufficient habitat for such wide-ranging animals, and these survivors of a once-larger population will disappear. Nevertheless, as a repository of the remaining subtropical lowland flora and fauna, Sukla Phanta must be considered a significant addition to the world's catalog of national parks and reserves.

Field studies in 1976 showed that, at most, 1,300 barasingha lived in Sukla Phanta, roughly one-quarter to one-third of the surviving wild stock of

The grasses that sprout following a burn set by herders and thatch cutters attract barasingha in large herds of mixed age and sex groups. By this time of year (January–March), the larger stags have already established their dominance and mated.

Narash and Rajesh Be

Dietrich Schaaf

both subspecies. They primarily occupy the grasslands in the southern third of the reserve, where they find the required food and shelter, shunning for the most part the open, grassy forests farther north.

November through December is the coldest period of the year on the *terai*, and occasional frost is not unknown. By December, grasses that flourished earlier during the monsoon rains are senescent and dry. Fires then sweep through the open country in the reserve. They are set by livestock graziers and thatch cutters; the latter, having collected the dry grass they need, now want easy access to the tall, stout flower stalks of certain species for use in mud-and-wattle construction.

Shortly after the first new grass appears following the burn, barasingha begin to congregate in large herds on Sukla Phanta proper and on neighboring Seta Khera Phanta. Together these two *phantas*, or grasslands, form the largest continuous grassy tracts in the area. It is here that the fires are usually set first, creating the extensive stands of nutritious new growth attractive to all deer, except the forest-dwelling barking deer and the sambar. A factor influencing congregation of barasingha may be the presence of nutrients in the grasses derived from the soil of these *phantas*. Visual contact between small groups of deer previously isolated by thick curtains of vegetation may also play a role; typically, ungulates of medium size form herds in open areas as one means to escape predation. In addition, late season breeding activity by young stags may, in part, account for the herd formation.

A mixture of sex and age groups is a characteristic of these large herds. During this time, stags carry antlers, which clatter together as the males spar in the still air of the peak morning and evening activity periods. Stags with the largest antlers rarely engage in these jousts and then only briefly if challenged with an antler thrust from a younger or smaller male. The larger animals apparently have established their positions in a social hierarchy, eliminating the need for such contests. These master stags probably accomplished most of the mating during the peak of the rutting season in November, keeping the younger, weaker, or less aggressive males away from receptive hinds. These earlier exertions may account for their disinclination to

Hot weather arrives at the Royal Sukla Phanta Wildlife Reserve in April. Seasonal ponds such as the one at left dry up rapidly, and the barasingha begin to frequent marshy areas for fresh grass and water.

engage in aggressive behavior as they rest after mating. Because the hormone levels responsible for triggering the rut decline slowly, less dominant animals, which had little chance to mate before, continue to challenge one another and occasionally test the masters as they strive for ascendancy. Indeed, a stag is probably from three to five years old before he can mate successfully. Such a breeding pattern is believed to benefit the population by insuring that only the most fit males, judged by their ability to attain and hold dominance, pass on their genes.

As the weather warms up during February and March, the deer remain grouped on the south-central grasslands of the reserve. The densest barasingha concentrations occur during March, with the majority of the population frequenting only a few thousand acres. Herds of eight or nine hundred deer have been counted. The seasonal formation of these herds in the same area each year makes possible annual counts to check population size and trend.

Stags begin to drop their antlers in March, the older ones being the first to do so. Without antlers, master stags lose dominance, indicating that the presence of antlers, as well as their size, is important in social organization. New antlers quickly begin to grow, but initially they are of little use as social organs since they are soft and highly vascularized by blood vessels for the next five months. Later in March the deer begin to molt, shedding their grayish, shaggy winter coats for the sleek, reddish brown pelage worn during the coming hot season and monsoon.

Truly hot weather commences in April. A strong, desiccating west wind, locally known as the *loo*, blows almost daily, and seasonal ponds on the grassland dry rapidly. Despite a high water table, which keeps the grasses growing even during this driest of seasons, the best grazing is temporarily exhausted where the deer have congregated for the past three months, and large herds on the south-central grasslands decline. Barasingha now appear more frequently in the southeastern portion of the reserve where an extensive marsh provides water and fresh grass.

Since barasingha in Sukla Phanta avoid areas frequented by livestock and herdsmen, cattle and domestic water buffalo grazing in this marsh earlier in the year may have kept the deer from using it sooner. As the marsh grasses grow tall and rank toward the end of the dry season, livestock are gradually withdrawn to neighboring village grazing grounds. Barasingha then move in, in response to either renewed sources of food and water or the absence of livestock, or both. Barasingha are far more catholic in their tastes than domestic cattle, and they will consume even the coarsest grasses as the season progresses. The deer never entirely desert the south-central grasslands where they had congregated earlier, and some animals can almost always be found there, even at this time of year. Reports from the field say that livestock grazing was eliminated from Sukla Phanta in 1976; observations made there today might indicate if barasingha distribution on the southern

grasslands has changed as a consequence.

By late May and early June, the sun blazes forth more fiercely every day, and temperatures regularly climb above 100°F. Although occasional violent storms sweep down from the hills to the north in the early evening, they often bring little more than wind and lightning. Eventually, the breezes hold steady from the southeast, signaling the start of the monsoon season in late June.

When the rains arrive they are steady and slow, unlike the gusty thunderstorms of a few weeks earlier. Frequent interludes of bright sunshine and the high humidity create an enervating hothouse atmosphere. Permanent streams soon overflow, and others refill their dry beds. Mud, water, and lush grass dominate the countryside, and terrestrial leeches lie in wait for warm-blooded hosts, including field researchers, in the flooded grasslands. Yet despite the discomfort and inconvenience caused by the rain, I find the profusion of life engendered during the monsoon season fascinating. Almost every day brings its small adventures of discovery—green and gold frogs clinging to the wet leaves, mushrooms with lacy curtains hanging from their caps, a three-foot monitor lizard whose hide in the sun looks as though it had been decorated with maroon and yellow beadwork, or the cleverly stitched leaf nest of a tailor bird.

The larger animals are scattered and difficult to see during the rains. We know that the barasingha are raising the season's fawns, and sometimes hinds can be glimpsed briefly as they nurse their single young. The fawns are left on their own much of the time while their mothers graze or rest elsewhere. This behavior, common to many ungulate species, actually helps the youngsters escape predators because they are less conspicuous in terms of numbers, attention-getting movements, and perhaps even scent. After a week or two spent hiding in this fashion, the fawns join groups of older animals, although not always in the company of their mothers. Hinds and their offspring seem to meet primarily so that the latter can nurse. Recognition, even after lengthy separation, is by odor, but fawns do sometimes get lost. From an early age, fawns begin to nibble the grasses that will constitute the bulk of their diet after weaning.

By late August, stags begin to rub the now dead and dry skin, or velvet, from their fully developed antlers. The older stags again take the lead in this. As the rutting season approaches, the drawn-out calls of the stags resound mournfully during the night and early morning hours. Master stags now also engage in challenges to renew their dominance, which will later determine their access to receptive hinds. Much of their behavior is ritualized, consisting of gestures and posturing, and there are few serious fights.

When mating begins, stags frequently test the hinds they encounter by sniffing the anogenital region, searching for those in heat. When a likely prospect is found, a stag accompanies her until she will stand for copulation. In this mating pattern, barasingha are unlike their near relatives,

A thatch cutter collects grass in the Sukla Phanta Wildlife Reserve. In Nepal, grass is used in house construction and grass cutting is permitted for one month, during December and January.

Chérine Le Blanc-Schaaf

Dietrich Schaaf

the American elk and the European red deer, which maintain harems during the rut. For elk, keeping the harems together and defending them against interlopers is hard work, and master stags enter the cold northern winters in debilitated condition. Barasingha, however, enjoy a milder climate, and since stags often stop to graze and rest even during the rut, they are better able to keep up their strength.

Because much of it takes place at night, rutting activity in Sukla Phanta is infrequently observed. Also, grassland vegetation after the monsoon is at the apex of its development, with perennial species sending up tall, flowering stalks that further obstruct vision. In addition to calling, or bugling, during the rut, stags regularly wallow in mud, using the same sites each year. They thrash grass with their antlers and walk about with it caught up in the tines, carrying their heads stiffly so as not to dislodge the fragments. The accumulated grass may make the antlers seem even larger and more formidable to potential rivals.

During the winter before grasses are burned, barasingha remain scattered in small groups, often hidden by the senescent vegetation, which closely resembles their winter coats in color. Most sightings still occur on the south-central grasslands, indicating that throughout the year only about twelve square miles support most of the population. Once new grass grows after the winter fires, the annual cycle of barasingha activities is complete, and the animals again begin gathering in large herds during January and February.

In most respects the yearly cycle of activities in Sukla Phanta reflects that of the barasingha in its other enclaves, although the timing of events may differ in various parts of the range, depending on seasonality and other environmental factors. For example, in Kanha National Park in central India, where the last population of the southern subspecies survives, seasonality has a greater effect on distribution. Barasingha there move several miles between monsoon and dry season ranges in response to the availability of water and food. In Sukla Phanta, deer movements in response to seasonal change are much more localized.

The barasingha of Sukla Phanta were prospering when I last observed them in May 1976, despite poaching and other human incursions still going on at that time. A modest increase in deer numbers between March 1975 and March 1976 suggested that the population was indeed growing. Adult deer were taken by tigers, and circumstantial evidence indicated that jackals were preying upon the fawns. Such predation helps to moderate population growth and removes sick and less wary individuals. Moreover, it provides a livelihood for the endangered tiger, also part of the ecosystem that we hope will be perpetuated in Sukla Phanta Reserve. Wolves, wild dogs, and striped hyenas have all disappeared from the reserve over the past two decades, so predation on deer in the area may be less intense than it once was.

In 1978 the Nepalese authorities announced that Sukla Phanta Reserve would be doubled in size and take in

Fires sweep through the reserve as cartloads of thatch are hauled away. People come from as far as thirty-five miles for the harvest. The fires are set to insure a plentiful supply of grass for the next season.

agricultural land on its eastern boundary, as well as a small, nearby hunting preserve where a few barasingha survive. Villagers now living inside this extension will be resettled elsewhere. In time, this enlarged habitat could support an expanded barasingha population, as has been the case in Kanha National Park, where additions to the park have led to barasingha becoming reestablished in areas they formerly occupied.

But despite laudable progress in protecting and expanding Sukla Phanta, some unresolved difficulties remain to cloud the future of the reserve and the creatures living there. Some of these problems are peculiar to Sukla Phanta; others are of a more general nature. One problem that affects the barasingha wherever they occur today is the scattered distribution and small size of the remaining populations, a condition that can be an advantage in terms of species survival, but a disadvantage with respect to the welfare of the individual populations. On the one hand, the species is probably in less danger of extinction than if all the remaining deer were in one place and subject to the same local environmental fluctuations, but on the other hand, each population alone exists as a virtual island, vulnerable to unfavorable circumstances, including the pressure that could be exerted by surrounding human populations.

The proposed extension of Sukla Phanta Reserve could mitigate somewhat the dangers of this insular existence. If, as is hoped, the deer colonize the reserve extension, they will move away from the population center on the south-central grasslands, and if two herds become established, there is less chance that all the animals will be similarly affected should a local disaster occur. For instance, twice in the past ten years devastating flash floods swept through the southern grasslands of the reserve, causing extensive mortality among the wildlife. Although barasingha recovered each time, a herd elsewhere in the reserve would provide more assurance that future floods could not reduce the entire population to such dangerously low levels that other factors, such as disease, might lead to extinction in Sukla Phanta. To some extent this kind of discontinuous population distribution exists in nearby Dudhwa National Park in the Indian state of Uttar Pradesh and is now developing in Kanha National Park. In Dudhwa, in spite of recent additions to the park, the yearly monsoon floods still force the larger of two more or less separate barasingha herds out of the park into neighboring grasslands, where for up to seven months it must compete with settlers who are claiming the land for agriculture. Ideally, reserves and parks should incorporate sufficient habitat to meet the year-round needs of the species they shelter and be large enough to moderate the undesirable effects of insularity. Sukla Phanta appears to meet the first of these criteria, but this is not always possible

As the rutting season approaches in the fall, stags begin their struggle for dominance within the male barasingha social hierarchy. Much of their behavior at this time consists of bugling, or calling, and ritualized posturing and gesturing. Fights do break out, however, particularly between animals of similar size. Any edge in size of body or antler usually determines the winner.

M P Kahl Bruce Coleman

in countries where land for human use is a constant, urgent need.

Let us assume that the barasingha continue to prosper. Under favorable conditions the population is likely to grow until it reaches a plateau corresponding to the carrying capacity of the environment for that species. Here again, the isolation of the population will influence what happens next. When carrying capacity is reached, the deer will not be able to emigrate, increasing the risk of habitat overutilization and the danger of population collapse should food shortages and disease result. Since populations at carrying capacity are, in a sense, living on the razor's edge, some ecologists consider it prudent to limit numbers to lower levels. Management of this kind may not be necessary for some years to come in Sukla Phanta; in the meantime, knowledge of carrying capacity and optimum stocking rates should be developed so that it will be on hand when needed.

One may ask, why bother at all? Why not simply leave things alone and let nature take its course? The answer is that nature's way may be unaccept-

able if barasingha are to survive. Population ups and downs do occur naturally, but their consequences may be far more severe in a small reserve, where there is no chance for emigration or repopulation from adjacent areas, than in a vast wilderness such as once existed, incorporating thousands of square miles and much larger stocks of animals. The barasingha as a wild, free-living species cannot be removed from its environment, and for this reason the whole complex ecosystem that is Sukla Phanta should be the object of scientific investigations. This is also true because we wish to preserve not only a single species but an entire ecosystem as a living museum. A research program encompassing the major plant and animal communities found in the reserve might appear at first glance to be a monumental task, but gathering the biological data needed to plan for the future is probably the least intractable of the problems facing conservationists in Sukla Phanta.

By far the most difficult questions yet to be addressed involve the human population living in the vicinity of the reserve. Most people in the area exist at subsistence levels, and the population is growing even though resources to support it are declining. Already Sukla Phanta is considered the only place in a wide region where grass suitable for thatching houses can be found, and people travel as much as thirty-five miles to collect it during the month-long grass-cutting season allowed them each winter.

In comparison with the heavily exploited neighboring countryside, the reserve contains a wealth of resources—building materials, fuel, food, and most important, land that could produce crops and support livestock. Local people traditionally used many products of the forests and grasslands, and the poor, uneducated villagers see no good reason why the reserve should remain inviolate. It is always a temptation to sneak in and take what is needed. Now some of

Scattered herds of barasingha survive in northern India and Nepal, but, outside of sanctuaries, their numbers are decreasing.

C Rajesh Bedi

them will have to leave their homes and fields to make room for an even larger reserve. Eventually, resentment is bound to develop, dangerously escalating tensions in the face of ever decreasing resources.

One way to cope with such problems is to provide the people with benefits linked directly to the reserve. Parks and reserves have been heralded elsewhere as sources of revenue through tourism. This cannot be said yet of Sukla Phanta, and it is unlikely that the infrastructure needed to support tourism on a profitable basis will soon be available there. Furthermore, without a concerted effort by government and private enterprise, the profits of tourism often are not tangible at the grassroots level where they are needed most.

In the case of Sukla Phanta, special assistance to the communities surrounding the reserve may be needed to compensate the people for the existence of the reserve in their district. Compensation might take the form of programs to improve crops, livestock quality, or standards of health and hygiene, to name but a few possibilities. When funds and expertise for such programs are not available internally, aid could be provided by international agencies or the foreign assistance programs of other nations. Of course, assistance to the villagers should not be entirely in the form of handouts. Insofar as possible, the local citizenry must be involved in self-help schemes for the betterment of living standards. An added benefit might be that such programs would eventually become models for adjacent communities that do not have the advantage of being neighbors of the reserve.

While all this may look fine on paper, the obstacles to implementation are complex. They run the gamut from cultural and religious biases to the more usual bureaucratic red tape. But in the communities surrounding Kanha National Park, far to the south in India, programs similar to those just suggested were initiated as people moved to new villages to make room for additions to the park. Perhaps the same can be done for those living around Sukla Phanta. Certainly much remains to be done, in biological research and planning and in improving the lot of the villagers around the reserve, before we can say with assurance that the barasingha is secure in Sukla Phanta. □

War of the Yellow Jacket Queens

Resident and invading queen wasps battle to the death over a nest. The loser's body is dumped on the pile of vanquished queens, and the winner will soon face another invasion

by Robert W. Matthews and Janice R. Matthews
photographs by Raymond A. Mendez

Two V. squamosa *queens fight for possession of a nest and colony. The resident queen had taken the nest from a* V. maculifrons *queen, inheriting the smaller worker who has a hold on the invading queen.*

Their potent stings have earned yellow jacket wasps the respect of prudent people. These notoriously aggressive, common picnic spoilers, colloquially misnamed "ground bees," occur in great enough numbers, particularly during late summer and early fall, to become significant pests. Since 1973, we have been studying the biology of yellow jackets in the southeastern United States, especially the ecological and evolutionary forces behind their pugnacious manner. Competition, centered on nest establishment, has played an important role in the development of yellow jacket aggression.

Although the name "yellow jacket" is sometimes broadly applied to various species of hornets and wasps, we have been concerned with yellow jackets in the stricter sense, wasps of the genus *Vespula*. These typically have subterranean nests—paper-covered spheres, commonly ranging from baseball to basketball size and enclosing several roughly circular combs of hexagonal cells, suspended in a cavity below ground.

Yellow jackets undergo an annual colony cycle. In the early spring, overwintered queens awaken from hibernation and search out suitable nest sites, such as old rodent burrows. Within such a cavity the queen builds a small cup of shallow cells upon a short pedicel, providing each cell with a single egg. This brood emerges in late spring to become the first workers. With the aid of this additional labor force, the nest begins to expand rapidly, and the colony population increases steadily throughout the summer as new generations appear. In late summer, workers begin constructing larger cells, within which fully functional females (next season's queens) are produced. These emerge, together with males, in the early fall and mating follows. Males and remaining workers eventually die, but the fertilized queens enter hibernation until the next spring, when the cycle is repeated.

Concentrating on *Vespula squamosa* and *V. maculifrons*—the two types of yellow jackets most common in the southeast—we advertised for nest locations in local newspapers and were promptly overwhelmed by homeowners eager to donate their pests to science by having us remove nests from their yards and gardens. Each nest removal meant three trips. On the first, we located the nest and determined its actual identity (we received calls for everything from honeybees in house walls to bumblebees in haystacks). During a second, nocturnal trip, we killed the nest inhabitants while all were in residence. Finally, we made a daylight visit to carefully excavate the nest and wasps, which we bagged together and placed in a freezer or freeze dried for later analysis.

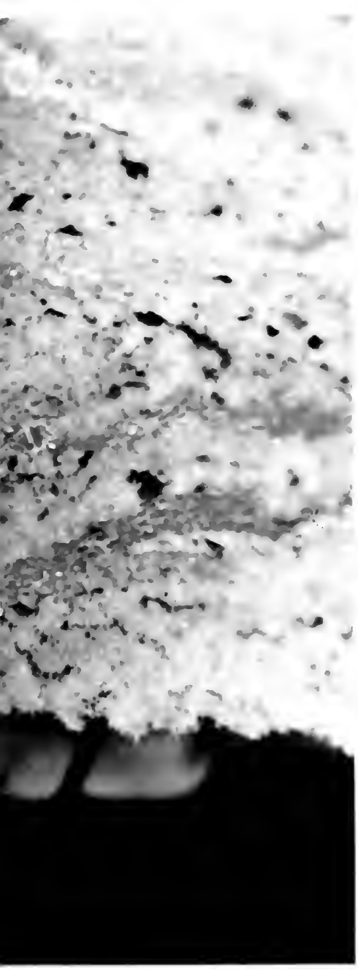
Upon excavating early season nests

in June and July, we found to our surprise that corpses of yellow jacket queens often littered the normally fastidiously clean nesting cavities and entrance tunnels to the nest itself. In addition to one reigning queen, we encountered as many as twenty-five other corpses in a single nest. How they came to be there and the cause of their death were perplexing questions. We reasoned that perhaps good nest locations were few, and subsequent queens were simply rediscovering cavities in which earlier ones had died from natural causes. But shortly, a second, unexpected finding led us to believe the queens had died a more violent death.

Dissecting yellow jacket nests in the laboratory, we found that many nests appeared to have a history of mixed occupancy by both *V. squamosa* and *V. maculifrons*. Specifically, the cells in the core of the earliest combs were tan and fragile like those we were accustomed to finding in *V. maculifrons* nests. Toward the periphery of these combs, we could easily discern a transition to slightly larger, gray cells of the more durable construction typical of *V. squamosa*. All the more recent cells were of this latter type. All of these nests were occupied by *V. squamosa* at the time of collection; nests that were occupied by *V. maculifrons* did not show traces of mixed residency. More than 80 percent of our *V. squamosa* nests showed evidence of a *V. maculifrons* heritage. Based on this evidence, we hypothesized that queens of *V. squamosa* had been taking over nests of *V. maculifrons*.

Such behavior is known as social parasitism. (In insects, a social parasite is a species that commandeers the nest of another in order to use its host as a work force rather than as a direct source of food.) Broadly speaking, two degrees of socially parasitic relationships have been discovered among vespine wasps. In the first, social parasitism is facultative, a behavioral option of the insect. Not only are the parasite queens capable of initiating their own colonies independently, they are also capable of invading established nests, eliminating the host queen, and laying their own eggs. For a time, the progeny of both queens toil side by side, but as host workers die they are replaced by workers derived from the parasitic queen.

The second form of social parasitism is obligatory, and the only course open



A V. maculifrons *worker adds paper to a yellow jacket nest, left. A queen of this species rarely builds more than 45 cells, and the workers are responsible for the cells over that number. When a* V. maculifrons *nest reaches 278 cells, it becomes an attractive target for takeover by a* V. squamosa *queen. The stinger of a queen, above, in this case a* V. maculifrons, *is reserved as a weapon against other queens.*

to the insect. The parasite queen is unable to begin a nest of her own or to produce workers. Invading a host colony early in its development, the parasite queen permits the host queen to remain alive until the latter has laid enough eggs to produce all the workers the colony will require. Then the host queen is killed, and the parasite lays the eggs that will hatch into males and queens.

To observe facultative social parasitism and other interactions between nest inhabitants, we moved our wasps into the laboratory. We transplanted nests into glass-walled observation boxes connected by plastic tubing to a hole in a windowsill, so that workers could travel freely back and forth to the outside to carry on normal foraging activities. We could have spared ourselves the considerable effort required to locate embryonic nests (those with a queen but no emerged workers) in the field had we been able to persuade a captive queen to begin a nest in our observation boxes. But so far, no one has been able to induce a *Vespula* queen to initiate construction of a nest in captivity.

Our first transplants were disappointing, for most failed to thrive despite attempts to duplicate the natural setting. A seemingly unimportant detail held the key to success. Knowing that larger yellow jacket nests hang securely in their soil cavities, we had been cradling the fragile embryonic nests in small wire hoops such as those used to dye Easter eggs. In nature, however, queens suspend their nests from fine root hairs so that, like a child's tire swing, the nest swings freely from its attachment point until, almost immediately after emerging, the first worker offspring add paper ribbons to the nest stalk, strengthening it so that it becomes more rigid. After gluing a slender thread to the apex of our transplanted queen nests and suspending them in the boxes, we were encouraged to see our transplant success rate improve markedly.

Within the glass-walled boxes we succeeded in staging social parasitism. Those workers who attempted to defend their queen were usually quickly dispatched by the invader. The alien queen, roughly three times larger than the workers, simply bit them in two through the abdomen or decapitated them. When the alien and resident queens confronted each other, the resultant contest for the nest was fierce and almost always fatal for the resident when she lost. Occasionally, both queens were killed in the struggle. The death weapon was usually the stinger, through which venom was injected into the victim's body at some tiny, vulnerable point. The workers also attempted to use their stingers, usually futilely, against the tough, outer "skin" of an invading queen.

We thought that one probable ecological correlate of this warfare might be slightly different seasonal cycles. To determine the flight season of parasitic queens, we captured flying yellow jackets with Malaise traps, unbaited gauze tents that intercept and collect flying insects. Used throughout three seasons of queen flight activity, our traps indicated that *V. maculifrons* queens were flying at least a week before *V. squamosa* queens. Peak numbers of *V. squamosa* generally followed, by a week or more, peak numbers of *V. maculifrons* queens. Furthermore, the number of flying *V. maculifrons* queens peaked sharply over a two- to three-week period, then declined abruptly as the queens began to establish nests. On the other hand, numbers of flying *V. squamosa* queens remained almost constant for nearly two months.

A second ecological correlate appears to be a shift in habitat over the nesting season. The actual distribution of the two species changes throughout the summer, a change that directly affects beleaguered gardeners and passersby. Early in the season, *V. maculifrons* nests occur with about equal likelihood among varied habitats. But once *V. squamosa* queens begin their usurpations, more and more *V. maculifrons* nests in disturbed habitats, such

Left: A V. maculifrons *worker attacks a* V. squamosa *queen that has alighted on its nest. Above: The* V. squamosa *queen has located and engaged the resident* V. maculifrons *queen in deadly battle.*

as suburban backyards, fall prey; only those in relatively natural settings, such as forests, escape being taken over. Thus *V. squamosa*, the species that is most troublesome to people, is the one they are most likely to encounter.

We predicted that queen nest-site searching behavior might be largely responsible for this pattern of nest distribution. Mature nests of both species produce approximately equal numbers of queens that enter hibernation in the fall. If both species were searching in an unbiased fashion for nest sites, there would be roughly equal numbers of both flying in any area. Perhaps *V. squamosa* queens preferentially search more disturbed habitats, whereas *V. maculifrons* queens comb all habitats. Analysis of the trap data by habitat type confirmed this. Traps in relatively natural settings, such as forests that belong to a university botanical garden, failed to collect a single *V. squamosa* queen, whereas traps in suburban backyards captured about equal numbers of queens of both species (46 percent *V. maculifrons*, 54 percent *V. squamosa*). Sighting records of queens flying in a seminatural municipal park during the same period corroborated the traps' evidence. Of some 346 queen sightings over two consecutive flight seasons, only 13 percent belonged to *V. squamosa*.

To better understand queen interactions, we closely monitored a portion of the same municipal park, approximately 1,000 feet of meandering stream bordered by a walking path. For three years, from April to June, we searched the stream banks daily for new nests from which we captured queens as they departed to forage, marked them individually with distinctive paint spots, and released them. Thereafter, by briefly recapturing these queens daily as they left the nest, we were able to track the fates of individuals and their nests and to estimate the extent of queen supersedure.

We made two surprising discoveries. First, nestless queens were attempting to take over many more established nests than we had anticipated. In forty-six monitored embryonic nests, the annual usurpation rate ranged from 23 to 37 percent over a three-year period, and multiple takeovers were common. (In 1976, one nest was successfully invaded on three consecutive days.) Many attempted usurpations failed. One embryonic nest we excavated in 1977 contained parts of at least six queens, none of which bore our marks.

A second revelation was that social parasitism at this early stage of the insects' life cycle involved queens of the same species. Of fourteen successful usurpations, all but one involved two *V. maculifrons* queens battling one another, and even in the single exception, the nest that the *V. squamosa* queen acquired was subsequently lost to another *V. maculifrons* queen.

We felt that such conspecific warfare might significantly affect yellow jacket population biology. Although the high mortality rate of embryonic nests has been known for some time, it is usually ascribed to physical factors, such as the vagaries of early spring weather. Postulating that queen usurpation might also be a contributing cause, we again simulated takeover attempts in laboratory nests.

In the field, we captured queens exhibiting typical nest-searching flight and introduced them into the entrance tube of an established laboratory colony. In the free-for-all that ensued, the resident queen had a clear advantage, winning nine of eleven encounters. However, victory for either queen sometimes had a high price. Two successful defenders and two successful usurpers later died of battle injuries, leaving orphaned colonies destined to die prematurely. In nature, where repeated queen usurpation attempts occur regularly, the chance of a given nest being orphaned must be high.

Researchers working with other yellow jacket species are finding similar cases of regular queen supersedures, so that this behavior seems to be the norm among these wasps. A shift in antagonists over the season probably also is normal. Clearly, conspecific queen combat accounts for a high percentage of embryonic nest failures in the common yellow jacket species of southeastern North America. As a nest becomes larger, conspecific queen takeover attempts become less frequent, but interspecific attempts increase. When *V. maculifrons* and *V. squamosa* clash, usurpations normally peak when the host nest averages 278 cells and already contains a significant number of workers. (A *V. maculifrons* queen is able to construct about 45 cells on her own before her first workers emerge.) Thus, throughout the whole process of establishing a colony, the ability of a yellow jacket queen to initiate and defend a nest carries a very heavy risk. The biggest single factor limiting yellow jacket nesting success may not be the number of available nest sites or favorability of hibernating conditions or spring weather, but rather the abundance and behavior of other queens.

These discoveries provide support for some hypotheses of considerable current interest in evolutionary biology. Borrowing from game theory,

two Englishmen, John Maynard Smith and Geoffrey Parker, have made predictions about the outcome of contests between two organisms competing for specific resources, such as mates or territories. In their terminology, the yellow jacket situation would be an *asymmetric contest*, in that the payoff—possession of an established nest—has vastly different values for each contestant. If the resident queen is defeated, she stands to lose everything, whereas the intruder stands to gain a great deal by taking over, and providing she survives to try again, she will be no worse off as a loser than if she had made no attempt. When the payoff is so out of balance, Maynard Smith and Parker predict a savage, "escalated" contest threatening serious injury and possibly death to one or both contestants.

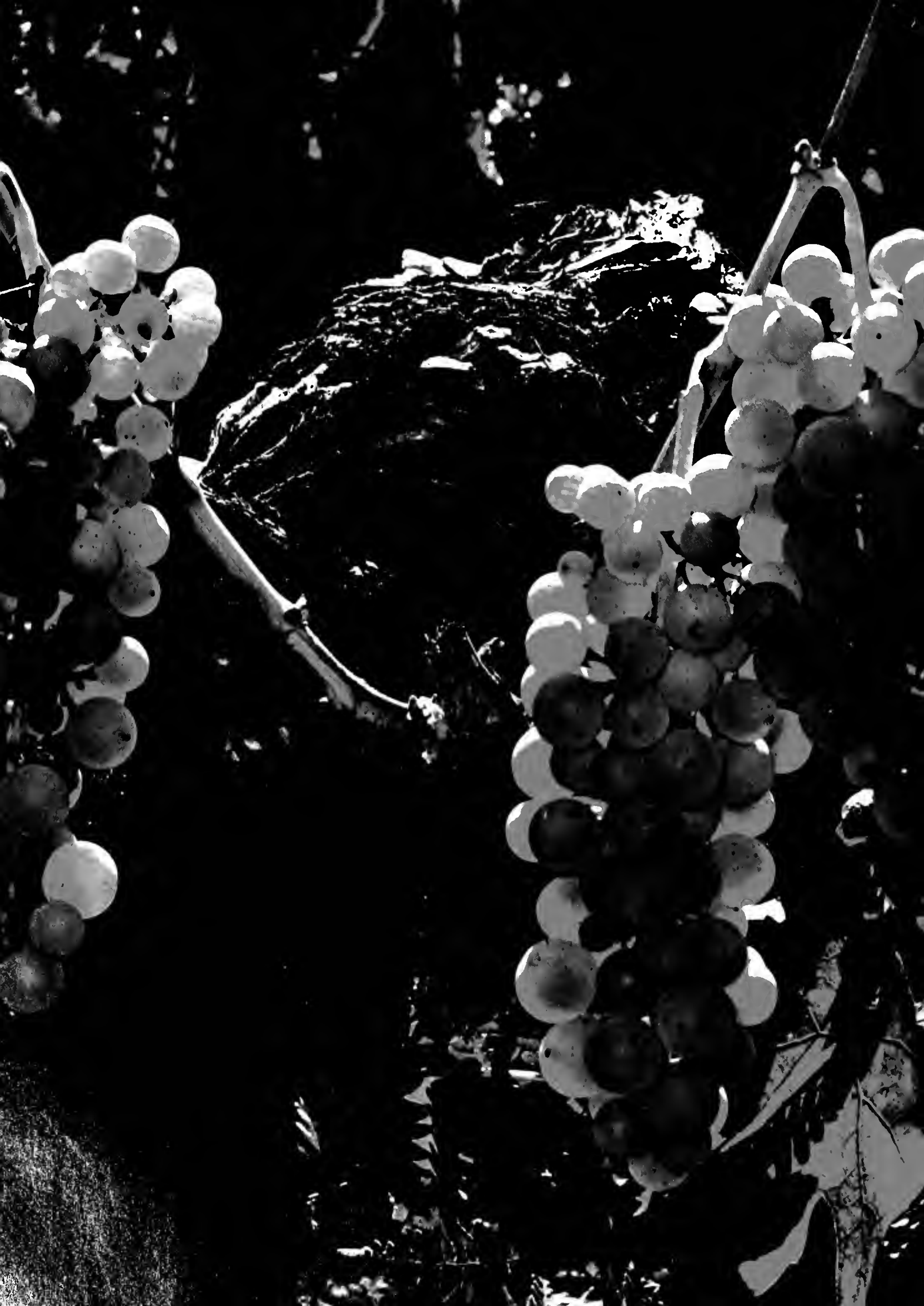
Two queens, a V. squamosa *and a* V. maculifrons, *are joined in a battle that will end in death for one. The combatants maneuver to get into position to use their stingers, the weapon that will decide the outcome. There are a few vulnerable chinks in the tough "skins" of the queens, and the contest is over when one of the queens manages to sting the other. The venom injected is so powerful that death is virtually immediate. This battle became so fierce that both queens, locked together, fell off the nest. They continued the contest on the floor of the nest chamber until the* V. squamosa *queen emerged victorious. She was then able to claim the* V. maculifrons *colony.*

A V. squamosa *queen feeds on a liquid produced by the larvae in a* V. maculifrons *nest she has invaded. She will feed the workers of the colony with this substance, thereby pacifying them.*

Game theory may help explain the evolution of queen aggression, but what about workers in an invaded nest? When a queen tries to force her way into a nest, workers avidly enter the fray and readily attack the invader, but being reproductively sterile, they would seem to have little reason for interest in a contest's outcome. At first, we postulated that workers in orphaned nests might even readily accept an invading queen since her presence would assure the success of an otherwise doomed nest. Experiments demonstrated otherwise. Workers in orphaned nests remained highly aggressive toward intruders. In the laboratory, when we introduced queens into queenless nests, yellow jacket workers quickly responded by mobbing the intruder, biting and attempting to sting, in a battle so fearsome that the nest was often severely damaged.

We saw a possible explanation of this worker pugnacity when some orphaned nests began to produce males. The queen's presence inhibits yellow jacket worker ovarian development; however, soon after the loss of the nest queen, worker ovaries develop rapidly and produce viable unfertilized eggs, which in Hymenoptera result in males. In an orphaned nest, workers have a rare chance to contribute their genes directly to the next generation by laying male eggs; if they accept a foreign queen, they lose this opportunity. Even if only a few of their own offspring live to mate, it would be more adaptive than continuing to toil for a totally unrelated queen and her offspring. Hence Maynard Smith and Parker's theory would also account for the hostile behavior of orphaned workers toward invading queens.

So far, investigation of one facet of yellow jacket life history, queen behavior, has provided clues to the causes of yellow jacket aggression, species distribution, and abundance. Further investigation of the secretive habits of these underground societies will no doubt produce more insights into their ecology and behavior. □



BECAUSE nature provides only the promise of great wine
these delicate Sauvignon Blanc grapes, the winemaker must guide a
guard the young wine for it to fulfill that promise. Every step we tak
we take with care because THE WINE REMEMBE

THE WINERY OF
ERNEST & JULIO
GALLO

Ernest & Julio Gallo, Modesto, CA

The Art of Being Huichol

Presented with a disconcerting assortment of his culture's artifacts, a Huichol Indian helped to design a coherent museum exhibit

by Kathleen Berrin
photographs by Jim Medley

Unlike many subjects chosen for museum exhibits, the Huichol Indians are not dead but emphatically alive. Approximately 10,000 to 14,000 Huichol (pronounced Wee-chol) live in isolated mountain communities in the rugged Sierra Madre Occidental of Jalisco and Nayarit, Mexico. There they continue a timeless and remote existence, escaping many of the pressures and homogenizing tendencies of the modern world. While their way of life as subsistence agriculturists is poor and difficult, their highly developed religious tradition and strong belief in the sanctity of "being Huichol" give their culture resilience and sustenance.

To be Huichol means to live a good and devout life according to ancient custom; to travel literally and figuratively on a quest for religious enlightenment that is considered both beautiful and right. A dramatic example of this quest on a communal level is the peyote hunt, a ritual search for primeval origins that takes a group of pilgrims, under the leadership of a shaman, on a rigorous journey through the San Luis Potosí desert. The Huichol are also obliged to perform religious devotions on a private level. Personal offerings are taken out to sacred spots in the Huichol landscape or placed on special family shrines as prayers or tributes to particular deities.

As the curator responsible for developing a temporary, traveling exhibit of Huichol art for the Fine Arts Museums of San Francisco, I was concerned with the Huichol regard for much of their culture as a sacred and beautiful endeavor. Fortunately, I was able to receive the guidance I needed from a Huichol informant.

At first, the conventional resources seemed more than adequate. Two well-documented collections had been amassed by Carl Lumholtz and Robert Mowry Zingg, the foremost students of Huichol culture. In the process of collecting for the American Museum of Natural History, Lumholtz had visited various Huichol communities on three separate occasions, beginning as early as 1890, and had exhaustively documented his impressions of Huichol life and material culture in several books. Similarly, Zingg had traveled through the area in the mid-1930s, gathering artifacts for the Museum of New Mexico at Santa Fe. There were also other fine public and private collections of contemporary material. We certainly had enough to do a comprehensive picture of Huichol Indian art from the turn of this century to the present.

After visiting these various collections and selecting more than two hundred objects, I envisioned an exhibit arranged in three categories: costumes and textiles, ceremonial objects and votive offerings, and yarn paintings (colorful yarn collages that illustrate traditional Huichol myth-histories). The costumes and textiles lent themselves beautifully to display, for the Huichol are consummate weavers and embroiderers and their textiles bear a variety of symbolic patterns. The yarn paintings, a contemporary art form made primarily for the tourist market, also were visually appealing and intrinsically interesting. But a challenge was presented by the ceremonial objects and votive offerings—beaded gourd bowls, feathered prayer arrows, shamanic wands, round shields of yarn, sacred boards with mirrors attached to them, "god's eyes," unpainted incense burners, and crude stone disks with strange symbols. These objects were interesting on an anthropological level, but not easily understandable or immediately aesthetic in Western terms.

One could hardly put a prayer arrow on a pedestal or dramatically light an

Singly and in strings, beads were pressed into beeswax to decorate this wood deer and gourd bowl, collected by Carl Lumholtz in the 1890s. Such votive objects accompanied prayers for luck and well-being.

AMNH

The original image of Grandmother Growth was located in her cave, near a spring where children bathed. The figure served as a prayer for the health of these children and for the continued flow of the water.

unpainted incense burner. While the offerings were enhanced when placed out on the stark Huichol landscape or when grouped together on a shrine, we could not re-create such settings with confidence. The objects came from many different time periods and locations, and the documentation about their meaning, although substantial, was uneven.

As the time for the exhibition drew near, I knew we should try to communicate The Art of Being Huichol, but did not know how to present the theme adequately. The Huichol have a rich sense of aesthetics and proper ordering, and they extend these principles to many aspects of ceremonial life besides objects. Huichol artfulness goes further than the Western concept of design, and this seemed to be the crux of the problem.

It was at this point that I had the good fortune to meet Mariano Valadez, a Huichol Indian, who, after leaving his village, had lived for some time in Guadalajara—and in Los Angeles—but who remained nonetheless very committed to his cultural traditions. I was introduced to Valadez by Susan Eger, a contributor to our exhibition catalog, *Art of the Huichol Indians*, and an enthusiastic student of Huichol culture, who had spent three years in the Sierra. Although the scholarly text for the catalog had long been completed, meeting Mariano in time to draw on his expertise for the exhibit was a godsend. Susan assisted as interpreter, and her experience in the Sierra and Mariano's trust in her served as an important catalyst. We immediately became a team.

For our first session together, Mariano and Susan came to the museum's storage area, where I had carefully laid out all the objects in long, neat rows. I was convinced that our sessions would have a sense of order about them if we proceeded by working down the tables, where everything was placed according to the organizational format we had used in the catalog (all the prayer arrows were grouped together, as were all the beaded bowls).

Since the focus of the exhibition, as Susan hastened to explain in Spanish, was to portray The Art of Being Huichol from a Huichol point of view, we were interested in capturing Mariano's insights and hearing anything he had to say about the objects. I set the tape recorder going, expecting to record several statements about each artifact, which Susan could later translate into English for use on the exhibition labels. But to my dismay and flowing adrenalin, Mariano did nothing for the first several hours but move erratically from one table to the next, studying the displayed objects in a long and intense way, looking agitated.

I asked if there was anything too sacred to show, but he said that wasn't the problem and would say nothing more. In retrospect, I think he must have experienced an enormous shock at seeing bits and pieces of his culture, spanning more than one hundred years and innumerable communities. In any case, there was not much we could do but try to cope with an increasingly uncomfortable situation. Finally, Mariano began to talk about the objects in a very halting way. Only as we all became more relaxed did a kind of working style evolve, based on a slow and methodical pace, a sense of seriousness or solemnity, and Mariano's concern for giving correct information.

My categories, of course, were all wrong, and Mariano soon began to obliterate them by moving objects around in a fashion that made sense to him but not to me. Susan explained to him that we needed to organize the ceremonial objects in six or seven groups, each with a distinct theme. There could be any number of objects in a single grouping, and we might think in terms of creating ceremonial "settings," or scenes, if that was appropriate.

The incompleteness of what was represented on those tables must have astounded Mariano—particularly since the objects had been selected according to type, medium, material, and iconography and not with any thematic categories in mind. As Mariano continued to move things around, he began to be frustrated because certain key items were missing, such as a particular kind of prayer arrow or a special type of object with a mirror. Although I asked Susan to explain to him that we were only trying to portray Huichol culture, not re-create it, and that there was only so much we could do with a four- by eight-foot display case, this point of view was not totally acceptable to him.

The Museum of Cultural History, UCLA

While some "missing" objects were optional, others were absolutely not, and we began to list the most critically needed things in the hope that they might later be obtained.

Sometimes in this process of arrangement and identification, Mariano would feel an object was tremendously important and discuss it with far more detail than was necessary. Other objects—particularly those collected by Lumholtz in the 1890s—he was unsure of, probably because they represented communities different from his own or an older tradition that had died out. He refused to comment or even make an educated guess about an object if he was uncertain. He would simply shake his head and say that he would like to take pictures of it back to the Sierra to ask his family. Even when he heard the documentation of Lumholtz or Zingg, he wasn't satisfied. He would listen politely, then repeat that he would know much more after showing pictures to his family.

After several days of intense work, we had identified a little less than half the objects and still did not have the groupings well defined. Mariano announced that it was now time for him to go back to the Sierra with photographs. He had been planning a trip back anyway to help with the planting. When he returned in several weeks with the information and some additional required objects, our categories would be complete and everything would be defined.

I nervously thought about my production schedule, worrying that Mariano might not return from the Sierra in time to finish organizing the exhibit. But now that I was familiar with his reactions to, and attitudes about, the objects—and his reluctance to take liberties in their identification—I couldn't go back to a contrived presentation of beaded bowls and prayer arrows. Mariano had said that as long as we were going to do an exhibition of Huichol art, it should be a "true" one, it should be "right." Somehow, these simple words condensed into practical terms an essential part of "being Huichol."

This two-foot-high "god's chair," a votive object collected in 1966, is made of bamboo, hawk and parrot feathers, fur, yarn, and pitch. Although smaller, it is similar to the type of chair used by a shaman.

Mariano Valadez, in native dress, discusses the exhibit with Susan Eger, who served as interpreter and anthropological field consultant. The two continue to share their interest, now as a married couple.

After some weeks had passed, during which I anxiously watched the opening date draw near, Mariano did indeed return from the Sierra. His family had spent much time talking about the photographs among themselves, and they were pleased about the exhibit. Best of all, they had reached a consensus about the unidentified objects. I was surprised to learn how little of our material pertained to the peyote hunt, the ceremonial so well documented in the literature. Most of the objects, although integral to "being Huichol," were associated with more personal aspects of religious life.

Back in museum storage, the three of us worked feverishly to fill in the redefined categories. The Children's Drum Ceremony, or Fiesta of the Newly Sprouted Corn, would represent a child's first exposure to religious training. In this ceremony, young participants are magically transformed into hummingbirds by the shaman's drum and then "flown" to sacred spots in the Huichol universe. Time of the Arrows would bring together objects pertaining to a special rainy season offering, which is placed inside a hut constructed in the cornfield to insure a successful harvest. The Family Shrine, an indispensable part of every Huichol rancho, would include a multitude of objects promoting the good luck and well-being of individual family members. And the final ceremonial setting, the Cave Offering of Grandmother Growth, would be a deeply secluded shrine to this all-important and aged Huichol earth mother, so critical to making crops grow and sustaining life.

After the objects had been arranged, I brought in our museum designer, and we attempted to anticipate every possible installation problem. Mariano patiently answered our frantic questions: How many dried marigolds for the Children's Drum Ceremony? Just dime store mirrors for the Cave Offering of Grandmother Growth? Does this prayer arrow stand up or lie flat? Which direction does the sacred round board with mirror face? Is Time of the Arrows an outdoor or indoor scene? Does the woven mat fill the entire bottom of the case or just lie under certain objects? What on earth should we do with the stuffed rat? We took photographs of everything, trying to bridge the gap between Huichol rightness and Western aesthetics in a museum presentation. While it had been crucial to establish which objects went together in the presentation, once certain criteria were met the actual arrangement proved to be quite flexible.

The stuffed rat mentioned above, an object I now privately term "the great Huichol put-on," was collected by Zingg in the mid-1930s. With its associated woven basket, the stuffed rat was supposedly part of the ceremonial

This man's hat, made in a traditional style, is adorned with pigeon and hawk feathers.

equipment of the peyote hunter, prepared in commemoration of the rat who stole the fire in the peyote, a myth Zingg recounts at length. This information I had faithfully reproduced in the exhibition catalog. But to Mariano, the stuffed rat was nothing but an object of great hilarity. He had never heard of any Huichol using a stuffed rat of any kind, and neither had his family. The fact that it had sewn bits of red cloth for the eyes made it even funnier. Every time the subject would come up, we'd all break out in laughter. We finally resolved the dilemma by installing the stuffed rat in the corner of the children's Drum Ceremony setting as a kind of a joke, just peeking out from inside the lid of its basket. I still do not know the truth of the object—whether in a different Huichol time and place it really did have some meaning or was just a joke on ethnographer Zingg. I do know that the Huichol have a marvelous sense of humor and comic reversal, and with all due respect to Robert Mowry Zingg, he would not have been the first outsider to have been fooled.

There were other discrepancies between the objects that I felt were important and those that Mariano did, and we didn't always work in accord. Most of our disagreements involved the oldest material collected by Lumholtz. I found it hard to believe that Mariano couldn't get excited about very rare, old front shields or the spectacular beaded bowl and the deer figure that were beautifully executed by the artist Juan Antonio Minjares and carefully documented. My surprise was even greater when Mariano later mentioned that one of the most important objects in the exhibit was a single wood stick with a red ribbon tied through it. Clearly, there was no correlation between artistry in our culture and cultural importance in theirs.

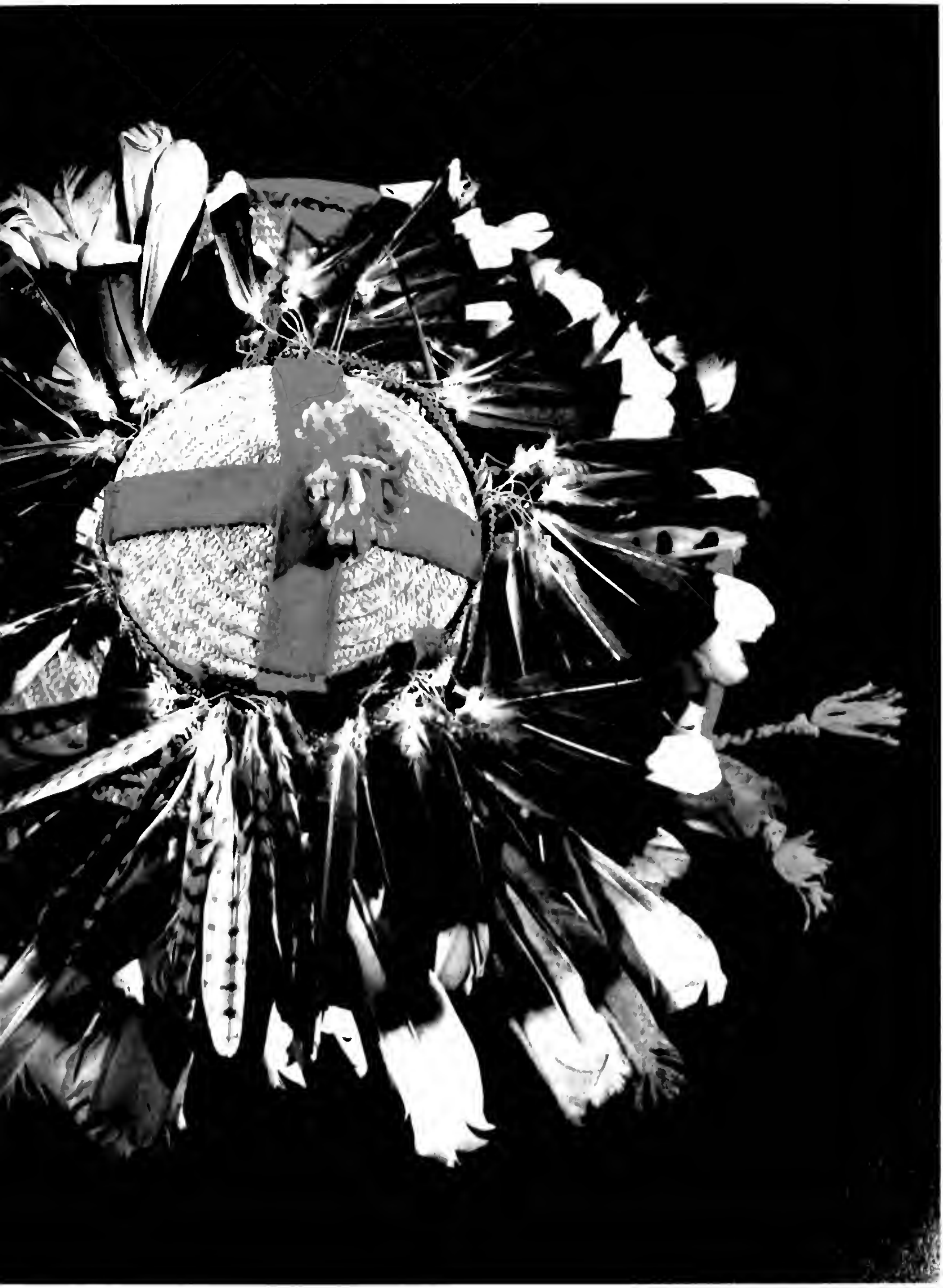
Mariano even lacked enthusiasm for what was, to my way of thinking, one of the most important objects in the show—Grandmother Growth and her accouterments. It didn't seem to matter to him that Lumholtz had spent pages discussing her intricate symbolism and face paint and her significance as a cave offering; that when Lumholtz saw the original figure in a cave in Santa Catarina, he was so impressed by it that he persuaded a shaman to reproduce this example for him to take back to the Museum. It didn't seem to matter to Mariano that she was collected in the 1890s and that, according to Lumholtz, there was a special, single way she was to be displayed with all her sticks. He kept insisting that the forked staffs she carried ought to be tied up into a bundle with some prayer arrows and placed together in another ceremonial setting. I stood by the historical documentation, saying that we had it on good authority that she did go together all in one unit and was a very important object. Mariano, who never did think too much of the figure anyway, finally just shrugged, and I kept Grandmother Growth intact.

Of course, the point of view expressed in the exhibit was largely that of Mariano and his family, and we could be criticized for allowing a relatively small group of insiders to speak for Huichol culture as a whole. But then, no two Huichol could be expected to re-create the same exhibition. Field researchers are beginning to realize that Huichol culture "as a whole" is a fiction, that there is a wealth of local variation in what was once thought to be a homogeneous unit. And I feel that Mariano's very thoughtful arrangement and resynthesis of historical material came far closer to correctness than any outsider's version could have. While there were discrepancies between Mariano's interpretations and those of Lumholtz and Zingg, by comparison, the copious documentation of the ethnographers seemed limited and one dimensional.

When Mariano finally did come to see the finished exhibition, I knew that all our efforts had been worthwhile when he remarked that it was "so beautiful it would make a Huichol woman cry." This shy summation touched me in ways I cannot begin to evaluate, but I like to think that the experience of developing the art of being Huichol must have been as meaningful for him as it was for me. □

The Art of Being Huichol will be exhibited at the American Museum of Natural History from November 7, 1979, to February 10, 1980. The exhibition was organized by the Fine Arts Museums of San Francisco and sponsored by the National Endowment for the Arts and the Museum Society.

Eger-Valadez Collection



Radio Bush Baby

Tracking a small primate by transmitter as it makes its nightly rounds in search of food, sex, and a place to sleep

by Robert D. Martin and Simon K. Bearder

The lesser bush baby lives in wooded savanna over vast areas to the north, east, and south of the West African rain forest belt—from Senegal to Sudan and down through East Africa, South Africa, and Angola. This diminutive primate is treated as a single species, *Galago senegalensis*, in all the major textbooks, although there are good reasons to doubt that such an enormous range is occupied by one interbreeding population. Whatever its taxonomic status, the lesser bush baby is certainly an adaptable creature; parts of its range cover some of the most extreme ecological conditions encountered by primates in Africa. For this reason, and because bush babies retain many characteristics of the ancestral primates, they seemed an appropriate subject for a long-term field study. In the northern Transvaal region of South Africa where this study was conducted, lesser bush babies (recognized as a local subspecies, *G.s. moholi*) are abundant, and laboratory studies by Gerald Doyle and his coworkers at the University of the Witwatersrand had already established many of the basic behavioral and reproductive features of this subspecies.

Vision is important to the lesser bush baby, despite its nocturnal habits. The light-reflecting tapetum, located behind the retina, aids the animal visually as it makes its way through the trees.

n Crampton

In recent years, field studies of primates have become increasingly quantitative in nature in an attempt to relate precisely measured aspects of behavior to ecological features. Such exact studies had hitherto been almost entirely restricted to diurnal primates because of the more favorable conditions for direct daytime observation. Yet there are good grounds for concluding that the ancestral primates were nocturnal, as are the majority of the most primitive living primates, the prosimians (lemurs, bush babies, pottos, lorises, and tarsiers). A comprehensive survey of primate behavior and ecology must therefore include at least some nocturnal species.

One of us, Simon Bearder, had already done some work on the behavior and ecology of the lesser bush baby in the northern Transvaal. That study had been conducted in a nature reserve set aside on a farm called Mosdene, covering almost 15,000 acres and run by the Galpin family for more than sixty years. More than half of the farm has been left virtually in the wild state by the Galpins, and their rotation of grazing by Bonsmara cattle has done little more than replace the influence of a number of large wild herbivores that have been eliminated in the region. Surviving mammals—impala, kudu, warthog, aardvark, jackal, aardwolf, springhaas, hare, bush squirrel, vervet monkey, genet, and various mongooses—are still quite abundant. There is also a rich variety of bird species, representing the major attraction for the many naturalists who visit Mosdene each year, and numerous reptiles, including monitor lizards. The Galpins kindly agreed to a further two-year, detailed study of the lesser bush babies on their reserve, and our project subsequently took shape, lasting from August 1975 to September 1977.

Already established was that the lesser bush babies of the region forage alone at night, although they may form resting groups in the trees during the daytime, and that their diet consists exclusively of animal prey (largely arthropods) and gum taken from *Acacia* trees. From laboratory studies we learned that each female bush baby may produce two litters of two infants a year, with a gestation period of approximately 120 days. But in the absence of detailed quantitative studies, their natural behavior and relationships with specific ecological features had not been established. In particular, no prior study had involved systematic following of known, marked animals.

Using traps at strategic positions in the main study area of 0.4 square mile, we were able to trap the entire local population of thirty-five bush babies over a period of a few months; thereafter we regularly trapped as many animals as possible once each month in order to keep a detailed check on their body weights and reproductive condition and to verify recruitment into, or loss from, the study area. (One interesting fact that emerged incidentally was that the bush babies were most likely to explore new trap sites in the bright light of the full moon and rarely did so under conditions of poor illumination. This emphasizes the importance of vision to these creatures.

even though they are nocturnal.)

The key to the study lay in the use of ready-made radio transmitters with individual frequencies, fitted to each bush baby prior to its release. The radio signals, which were used to trace individuals to their sleeping trees and to identify the composition of sleeping groups, led to our first significant finding. Although it had been widely reported that lesser bush babies live in family groups, we found that daytime sleeping groups are extremely variable in composition. The most frequent links in the fluctuating sleeping associations were between mothers and offspring and between particular adult females. A number of adult males slept within the associations, but only one at a time. While some males regularly gained prior access to any females or young within their ranges, there was no evidence for exclusive pair formation among individual adult males and females.

In the northern Transvaal, identification of lesser bush babies in sleeping groups, even in the absence of radio belts, was greatly facilitated because the animals rarely use proper nests, simply sleeping in a suitable tangle of branches a few feet above the ground. There was an overall preference for sleeping in one particular tree, *Acacia tortilis*. This tree, aptly named the "wait-a-while," is densely covered with both straight and recurved thorns. As a sleeping refuge during the daytime, it doubtless offers the greatest security available for a bush baby. *A. nilotica*, with a thorn density second only to that of the wait-a-while, was also highly preferred as a sleeping site, compared with less thorny species.

Home ranges averaged seventeen acres for adult females and twenty-seven acres for adult males. There was no evidence of exclusion of subordinate males to peripheral ranges, as has been found with a number of other nocturnal primate species; indeed, there was a slight excess of males over females in the study area. On close examination of the interactions between males, we learned that social dominance was related to age. With increasing age and gradual replacement of the population, there comes a time when a male no longer meets aggressive opponents within a particular home range

Gum exudes from an exit hole bored by a beetle larva onto the trunk of an Acacia karroo *tree, above. Such gums contain polymers of pentose sugars and are vital food sources for lesser bush babies. The animal at left is using its "tooth scraper" to remove gum adhering to the bark.*

where he has access to females (typically a harem of three). The male will then tend to confine his activity to this home range, from which he excludes only males of similar age and behavior. Thus, there are two classes of adult males: relatively young, lightweight adults (average weight 7½ ounces), with extremely large ranges overlapping those of numerous other males and females of all ages; and relatively old, heavier males (average weight 8 ounces), with somewhat smaller home ranges that exclude other socially dominant males from all but small zones of overlap, while tolerating males that remain subordinate. These old males, which invariably chased others and behaved in an assertive fashion, were not only the heaviest individuals but they also had very active marking glands on the chest and ventral surface of the scrotum, and well-developed thigh muscles. Thus, there seems to be a social division between males, based on age and dominance, even though no males are completely excluded from regular social contact with one or several adult females. (Lightweight adult males may encounter adult females briefly during the night and they may sleep with them in the same tree from time to time.)

Home ranges were fairly stable over the two-year period. On at least two occasions, however, subordinate males abruptly abandoned their usual ranges and migrated over a distance of more than a mile in a few nights to establish a new home range. In addition, at least six of the study animals were killed by large-spotted genets, which seem to be the major predators of the bush babies in that area. Genets were occasionally caught in the traps set for bush babies, and one animal was fitted with a radio, in a brief study made by Dan Freeman, to reveal some details of this predator's behavior. The animal covered a range of about one-half square mile in the course of a few nights, but it was remarkably consistent in its pattern of movement through its range from night to night.

Direct observation of the bush babies at night provided clear evidence of the importance of gums in their diet. On most of the occasions when bush babies were sighted, the supporting tree was a gum source. The major species supplying gum as food for the bush babies was the sweet thorn, *A. karroo*, but gum was also taken from the wait-a-while on numerous occasions. The gums are acidic, water-soluble polymers of pentose sugars that provide vital food throughout the year; they are particularly important in the dry winter, when arthropod food is scarce. Our study of gum production indicated an increase in the number of available gum sites in the dry season. The bush babies also obtain calcium for bone formation from the gums, a mineral poorly represented in insects.

The production of gums by acacias is a fascinating story in its own right. The process is initiated when wood-boring larvae of cerambycid and buprestid beetles and coccid moths form galleries in the trunks and branches. At the point of exit of the mature insect, or at holes made for the disposal of larval casts, a gallery passes through two layers where gum is mobilized on exposure to oxygen. The gum subsequently seeps through to the outside of the bark. Certain galleries containing liquid gum provide breeding sites for flies and it appears that irritation caused by their larvae, along with further attacks from wood borers, may also

stimulate the tree to produce gum. Once a gum lick is established, bush babies will visit it regularly and take any fresh gum produced. In some cases, when food is in short supply, the bush babies will eat old, dried gum and clear away thin films of hard gum from the tree surface.

The bush babies were apparently making use of their "tooth scraper," a special organ at the front of the lower jaw formed by extension and forward tilting of the four incisors and two canines. We had already noted the widespread occurrence of gum feeding among nocturnal primates possessing a tooth scraper and the exaggerated development of that organ in two highly specialized gum feeders, the fork-crowned lemur and the needle-clawed bush baby. Gum feeding probably exerted a major influence on the development of a tooth comb in the common ancestor of the lemurs and lorises. Confirmation of the use of the tooth scraper in gum feeding came from an unexpected source. The bait used in the bush baby traps was similar in consistency to fresh gum, and when applied to the trap baseboards, it formed a thin layer over the surface. As the color of the baseboards darkened through weathering we noticed that each one was riddled with tiny parallel scratch marks made by tooth scrapers. Thus, this special dental organ can definitely be used to aid in the collection of food substances from a wood substrate.

In the life of the lesser bush baby of the northern Transvaal, gum feeding—and hence the use of the tooth scraper—is of vital importance. In the course of a single night, a bush baby will visit at least 300 separate, potentially gum-producing acacia trees, covering a total distance of almost a mile along a tortuous path. Overall, the feeding strategy seems to be centered around the gum sites, which form the focal points of travel. Apart from the relatively brief periods when trees are in flower, attracting insects in swarms, bush babies take animal prey in an opportunistic fashion in the vicinity of gum sites, or while traveling from one site to another. In the study area, the net result was that bush babies were most commonly found in clumps of *A. karroo* trees at night, while during the daytime they were typically found in patches of *A. tortilis* or *A. nilotica*. Most of the bush babies tended to change their sleeping sites from night to night, and the most common pattern was for a bush baby to leave its sleeping site in a patch of vegetation dominated by highly thorny acacias at dusk, move through an area containing a fair number of *A. karroo* while feeding on gum and arthropods, and then stop at dawn at another sleeping site in a different part of the feeding area.

The most striking aspect of the whole study was the great resilience of the lesser bush baby at this southern limit of its geographical range. The extremes of temperature were remarkable. During the summer months, the bush babies were sometimes almost completely exposed to the full glare of the sun, with shade temperatures as high as 100°F, while in the winter months it was not uncommon for the night temperatures to fall below freezing. The bush babies responded to low temperatures by becoming inactive for long periods during the night, simply squatting in the crotches of trees or returning to a sleeping site. This indicates that reduction of energy expenditure is the most advantageous response to extreme cold. The northern Transvaal is also characterized by great unpredictability of climatic conditions (particularly rainfall and temperature) from year to year. Rainfall is limited to a few months of the year and varies from a maximum of thirty-five inches annually to a minimum of only eleven inches under severe drought conditions.

Given these unpredictable climatic conditions, it is not surprising that lesser bush babies are adapted for a high breeding potential. This permits them to respond rapidly to temporarily favorable conditions of increased rainfall and/or higher winter temperatures and to recover from catastrophic years when adverse climatic conditions result in high mortality. A striking contrast is found in the closely related Allen's bush baby (*G. alleni*), which inhabits the rain forest belt of West and Central Africa. There, climatic conditions are far more stable, and Allen's bush baby has a much lower breeding potential. A female Allen's bush baby can produce only one infant a year (25 percent of the lesser bush baby's potential) and has a longer gestation period (135 days as opposed to 120 days for the lesser bush baby).

This is a classic case of "K-selection" (Allen's bush baby) as opposed to "r-selection" (lesser bush baby). Under stable, predictable environmental conditions, an animal population is more likely to remain at the carrying capacity (K) of the habitat. K-selection will operate under conditions of keen competition between members of the species and will favor efficiency of resource use together with low reproductive turnover. On the other hand, where climatic conditions fluctuate capriciously from year to year, an animal species is unlikely to be at carrying capacity for long and there will usually be scope for rapid population growth. Here, r-selection (named after the intrinsic rate of natural population increase, or r) will favor higher reproductive potential, and competition for resources will generally be less intense. Such overall adaptive responses to climatic conditions are doubtless connected with the difference in social organization between *G. alleni* and *G.s. moholi*. Whereas the lesser bush babies in the northern Transvaal exhibit relative tolerance between males, there is fierce competition between male Allen's bush babies. This leads to the death or spatial exclusion of many males and the establishment of a more obvious harem system, with the home range of one successful male exclusively overlapping the ranges of about half a dozen females. This is to be expected, since competition for environmental resources is probably fiercer for Allen's bush baby than for the lesser bush baby.

This observation leads to a prediction that we hope to test in a further field study. Other populations of the lesser bush baby, for example, those to the north of the African rain forest belt, exhibit intermediate reproductive potential (single births occurring twice a year). This, in itself, suggests that those populations might belong to a separate species. More important, however, is the prediction that those bush babies should be subject to less variable climatic conditions than those of the northern Transvaal, and that their social system should exhibit an intermediate degree of tolerance between males. This study should lead to a more scientific examination of at least some of the relationships between the ecology and behavior of these nocturnal primates. □

Shortly after birth, an infant bush baby can cling firmly to a branch, such as this thorned acacia, although it is generally protected in a nest or tree hollow.

Saddleback Salvation

An island off the New Zealand coast has become a sanctuary for a bird that flies terribly and sings in dialects

by Philip Zeigler

Part of the price that has been paid for human development is the extinction of some plants and animals and the addition of others to the list of endangered species. The emergence of New Zealand into a modern nation is a good example of this process. One of the country's native birds, the North Island saddleback, almost became a victim of progress; but happily, it has been saved from extinction, thanks to an enlightened conservation policy, which uses islands as bird sanctuaries, and the tenacity of the New Zealand Wildlife Service. The story of this bird's recovery is fascinating; just as interesting are some discoveries about its behavior that have been made on the saddleback's island sanctuary.

When Polynesian settlers, the Maori, first reached New Zealand in about A.D. 800, they found that the heavily forested land, while rich in insects and birds, had only two species of mammals, both bats. Except for their introduction of dogs and rats and for their extermination of that famous flightless bird the moa, the Maori's impact on wildlife was minimal. The Europeans who settled New Zealand in the late eighteenth century, however, had a more disruptive effect. Like colonists everywhere, they viewed forests as an obstruction to agriculture and an inexhaustible source of timber. Within a century, New Zealand's forested areas had been reduced from about 70 percent of the land surface to less than 15 percent.

Taking their cue from Captain Cook, who had haphazardly scattered pigs and goats across the landscape, colonists imported animals as likely as cats and cattle and as unlikely as hedgehogs, ferrets, opossums, wallabies, and weasels. Some species were of obvious domestic or agricultural significance; others, such as the opossum, were imported in the hopes of creating a fur industry. A number of species were brought simply out of homesickness. Englishmen hunted for sport in England, and they were determined to have their pastime in New Zealand as well. If they found no indigenous game animals, they could at least import weasels and rabbits.

The combination of deforestation and foraging by exotic animals has, over the past century, deprived many native New Zealand birds of their habitats. Some species, such as the kiwi, are flightless, and many others have poorly developed capacities for flight. As land development continues, such native birds have been brought to the point of extinction. One such species is the North Island saddleback. Known to the Maori as the *tieke*, the saddleback is one of two extant species of wattlebird unique to New Zealand. Wattlebirds characteristically have fleshy, usually orange wattles, or pendants, in the corners of their beaks.

According to Maori legend, the god Maui and his brothers once snared and beat the sun to compel it to move more slowly and thus provide man with a longer day. Hot and thirsty from his encounter with the sun, Maui told the *tieke* to bring him water, but the bird refused. The angry god seized the *tieke* and flung it from him, his hot fingers leaving scorch marks on its back. These saddle-shaped chestnut colorations give the bird its European name.

A weak flyer capable of only 150 feet of sustained flight, the saddleback survives on insects found on the forest floor, where it is easy prey for cats and rats. A saddleback subspecies living on one of New Zealand's offshore islands was all but wiped out within a year after the accidental introduction of a ship's rat. Recognizing the threat to the saddleback, the New Zealand Wildlife Service began an urgent search for a sanctuary for the bird.

Fortunately, New Zealand has many potentially ideal wildlife refuges on its numerous offshore islands. Within a hundred miles of Auckland, there are more than thirty islands that can be used as refuges. Some are merely chunks of rock suitable only for sea birds, but others contain expanses of native bush and forest well suited for birds, such as the saddleback, that have been deprived of safe, forested habitats on the mainland.

When it chose Cuvier Island as a sanctuary for saddlebacks, the wildlife service reversed a trend toward extinction. In the late nineteenth century, the saddleback flourished on Cuvier, whose vegetation was described as "so dense, intertwined, and matted . . . that progress through it was difficult if not

In a painting published in Buller's A History of the Birds of New Zealand *(1888), an adult saddleback (top) is shown perched next to a specimen in immature plumage.*

impossible." Soon after, however, goats were introduced to the island to provide food for castaways. The gradual deterioration of the bush begun by the goats was completed by the domestic cattle and sheep introduced when a lighthouse was built. Even greater disaster followed the introduction of cats to the island by the lighthouse keeper.

Just how destructive even a single cat can be is shown in the history of a lighthouse keeper's cat on Stephen's Island in 1895—a case notorious in the annals of the New Zealand Wildlife Service. That cat had the dubious distinction of first discovering a new species of wren and then exterminating it, laying the dead birds, one at a time, on the keeper's doorstep each morning. The destruction by cats of Cuvier Island's saddleback population took somewhat longer, but within twenty years the bird had vanished from the island and was maintaining a precarious existence only on nearby Hen Island.

The rehabilitation of Cuvier Island took almost a decade. The isthmus on which the lighthouse keeper's livestock grazed was fenced in and five hundred goats and many feral cats were exterminated. Within a few years, the keeper's pet tabby was the only cat on the island. The keeper, however, was reluctant to part with the animal. A thick file of correspondence between various governmental agencies attests to the stubbornness of both the keeper and the wildlife service, but the wildlife service finally won and the cat was removed.

With the island predator-free, Operation Saddleback took place in 1968 with the transfer of twenty-nine birds from Hen Island to Cuvier Island. The birds were released at the bottom of a deep gully near an old pumphouse, a relic from World War II when a radar station was manned on the island. Annual spot checks indicated that the species was surviving and that pairs were establishing territories in various parts of Cuvier.

Two years after the settlement of the birds, Peter Jenkins, a zoologist at the University of Auckland, began a study of saddleback behavior on the island. Jenkins was immediately struck by some unusual features of the bird's social organization, which is based on pair bonding. Pairs of breeding adults form lifelong bonds that are among the strongest and most persistent reported in the passerine order of birds, which includes finches, robins, and sparrows. The members of a pair forage in proximity to each other all day, throughout the year. At night, they retire separately to roost in holes in trees, but they re-form as a pair in the morning. Each pair carries out all its activities—foraging, breeding, roosting—within an extremely small area of the forest. This small area of activity is undoubtedly related to the birds' limited flight range.

The male defends the territory against other males. Like other passerines, the saddleback uses distinctive calls and songs to define and maintain the integrity of his territory. Other passerine males usually conduct a kind of border patrol by moving around the perimeter of their territories while they sing. When these males encounter each other during their border patrols, they exchange the same territorial song. Countersinging, as this is called, is an announcement "to whom it may concern" that the territories are already occupied by males.

Jenkins was surprised to learn that, unlike other passerines, saddleback males sang their territorial songs from the centers, not the borders, of their territories, and that when two saddlebacks engaged in countersinging, they used two very different calls. He hypothesized that each male saddleback had developed his own personal territorial call.

To test this hypothesis, Jenkins first captured and banded more than one hundred birds. He then mapped the territory of each bird by following it through the dense bush and deep gullies. Finally, he tape-recorded each bird's territorial call. All this took several years and a great deal of effort, but eventually Jenkins was able to identify different male callers on the map and to study the differences between calls sung by birds in various locations.

As he analyzed the territorial calls with a sonograph, which produces a voice print, Jenkins realized that his hypothesis was mistaken. Saddleback males did not appear to have unique personal calls. Rather, he found that a

One of the New Zealand wattlebirds, the North Island saddleback is a denizen of the forest. The bird is a poor flier and hops about on the ground in search of insects, fruits, and young leaves.

New Zealand Wildlife Service

Saddlebacks from Hen Island have been released in this area of Cuvier Island by the New Zealand Wildlife Service. The birds have done well, and their population has steadily increased.

small group of saddlebacks living in the same region of the island will use the same call; furthermore, there are distinct geographical clusters of different calls. Jenkins calls such clusters dialects because they are geographical variants of a "language"—the basic species-typical communication pattern.

For example, saddlebacks living in the vicinity of the old pumphouse shared a territorial call that Jenkins calls the "pumphouse" dialect. Some distance away, at the top of a ridge, another group of saddlebacks used the "ridge" dialect, which is clearly distinguishable from the pumphouse dialect. Each dialect, although obviously a saddleback territorial call, is an audibly distinct song used by only a small cluster of birds. A saddleback whose territory lies along the boundaries of one or more dialects can choose which dialect to use. Such a bird would use the pumphouse dialect when engaging in a bout of countersinging with a pumphouse bird and a ridge dialect when responding to a ridge bird.

As he studied these dialect clusters over a four-year period, Jenkins observed that the clusters retained the same spatial distribution. New birds that were recruited into song groups eventually developed songs that were consistent with the existing song patterns of their neighbors.

To see how clusters and songs developed over time, Jenkins analyzed the songs of fathers and their sons. He discovered that each son moved about as far away from his father as possible and sang, not the song of his father, but the song of his immediate territorial neighbor. Furthermore, when an older male bird died, he was replaced by a young male that acquired not only the widowed female but also the dialect of the deceased male. Such evidence led Jenkins to conclude that specific dialects are passed on, not by genetic transmission or by paternal example, but by a process of cultural transmission from territorial neighbors.

According to Jenkins, the distribution of saddleback dialects on Cuvier Island is probably the outcome of a process of song learning and bird dispersion that began with the arrival of the transfers from Hen Island in 1968. The original Hen Island transfers probably brought their dialects with them. On a recent visit to Hen Island, Jenkins recorded many of the dialects now found on Cuvier Island. As the descendants of the original settlers matured and established new territories, they learned new calls that were imitations of their neighbors' dialects. In support of this hypothesis, Jenkins has found one or more Hen Island transfers living at the center of each dialect cluster on Cuvier Island.

While the existence of song dialects among other passerine species is well documented, the flexibility of the saddleback's song-learning capacity is extraordinary, even though its functional significance is unclear. Jenkins proposes that the variety of dialects helps to prevent inbreeding among saddlebacks. The movement of young males outside the parental dialect area suggests that the dialects are used as a reference system to avoid mating with close relatives.

This interesting problem was discovered because of the existence of the saddleback population on Cuvier Island, where the life history of individual birds is known in detail. This is a unique opportunity for future field studies of the ontogeny and cultural transmission of bird songs. But of equal importance is that the rehabilitation of Cuvier Island has been accomplished and the saddleback transfer program has been such a success.

On a recent visit to Cuvier, we had to hack our way through bush as dense, intertwined, and matted as it must have been eighty years ago. Moreover, we were able to band more than thirty new saddlebacks and identify almost twice as many old ones. On the basis of lessons learned from Cuvier Island, the New Zealand Wildlife Service has established saddleback colonies on several other islands. The North Island saddleback, endangered for almost a century, is now secure. □

"Chess Challenger-10 Wins Microchess Tourney"
—Personal Computing Magazine
February, 1979

Genius Offspring

"Its successor, the new Chess Challenger "7," is infinitely more powerful."
—S. Samole
President, Fidelity Electronics

Chess Challenger-10 did more than win the Penrod Memorial Microchess Tournament, it literally trounced all opponents. Personal Computing Magazine, February, 1979, reports, *"Chess Challenger-10 emerged as the easy victor with ten wins, two draws and no losses."*

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Unknown to the other companies, the undefeated tournament leader was being retired after the contest. Taking its place was a far more powerful chess computer, the Challenger "7." This new micro-computer had already beaten the official undefeated champ during a series of pre-tournament warm-up games at the factory. Its engineers explain that it is simply 14 months ahead in technology, in finer algorithm sophistication and in its superb performance.

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Within its seven different levels of play, you can enjoy every degree of chess competition, from beginner to tournament skill. Its total flexibility lets you change games midstream or switch sides with the computer to see how it would handle your dilemna. You can add pieces to your side or take away the computer's Queen. It is a superb teacher!

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Fidelity's Challenger "7" is able to analyze over 3,024,000 board positions. It masterfully handles over one thousand book openings and will respond to any deviation. Academic openings as Sicilian, French, Ruy Lopez and Queen Gambit Declined, are just some of the challenges to keep you on your toes.

It Knows Every Rule in the Book

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Final Results

Reprinted Courtesy of Personal Computing, February 1979, P. 66. (Darker lines ours.)

	CONTESTANTS		#1	2	3	4	5	6	7	8	9	Games Won	Games Drawn	Games Lost	FINAL SCORE	FINAL POSITION
1	MICRO-CHESS 1.0 (Heath H 8)	W		½	0	1	0	0	0			1	3	8	2½	7*
		B		½	½	0	0	0	0							
2	MICRO-CHESS 1.5 (TRS 80)	W	½		½	½	0	0	0			0	5	7	2½	6*
		B	½		0	0	0	½	0							
3	MICRO-CHESS 2.0 (PET)	W	½	1		1	0	0	½			3	4	5	5	4
		B	1	½		½	0	0	0							
4	CHESS CHALLENGER (3 Level)	W	1	1	½		0	½	½			2	5	5	4½	5
		B	0	½	0		0	0	½							
5	CHESS CHALLENGER (10 Level)	W	1	1	1	1		1	½			10	2	0	11	1
		B	1	1	1	1		1	½							
6	BORIS	W	1	½	1	1	0		1			7	2	3	8	3
		B	1	1	1	½	0		0							
7	SARGON I (TRS 80)	W	1	1	1	½	½	1				6	5	1	8½	2
		B	1	1	½	½	½	0								
8	ATARI *Did not play*	W														
		B														

* Note: Microchess 1.5 wins 6th place over Microchess 1.0 by virtue of the tie breaking analysis of relative strength of opponents.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun moves eastward through the stars of Virgo in October, while shifting rapidly southward relative to the equatorial plane. It moves into Libra about November 1. Since September 26, when the duration of day and night were equal, daylight has shortened noticeably; by the end of October, the day is only 10½ hours long, and sundown occurs at 5:00 P.M.

Moonlight brightens the early nighttime during the first week of both October and November. The full moon of October 5 is the harvest moon, that of November 4 is the hunter's moon. On each occasion, the retardation of moonrise (the delay in the time the moon rises from one night to the next) is minimal. The result seems to make the full moon last for three or more nights in a row. During midmonth in October and November, the moon is in the morning sky; it returns to the evening sky during the last week of each month. After the full moon of October 5, last-quarter is on the 12th, new moon on the 20th, and first-quarter on the 28th. After November's full moon on the 4th, last-quarter is on the 11th and new moon on the 19th.

Stars and Planets No planets appear on the Star Map this month. The morning planets, however, are in excellent position, especially just before dawn, when Saturn, Jupiter, the bright star Regulus (in Leo), and Mars are spread across the eastern sky in that order, from Saturn low in the southeast to Mars high in the south. Their motion will be easy to follow relative to the "fixed" position of Regulus and the other stars of Leo. The moon will add to the scene from the 14th to the 18th of October and from the 12th to the 14th of November. On each occasion, the waning crescent in the morning sky passes Mars first, then Regulus, Jupiter, and Saturn. In October Mercury moves from the constellation Virgo into Libra; Venus is in Virgo in October, in Libra in November; Mars moves from Cancer into Leo, Jupiter is in Leo, and Saturn moves from Leo into Virgo.

October 4: Perigee moon occurs 28 hours before full moon and will strengthen tomorrow's spring tides.

October 9: The star near the moon tonight is Aldebaran, in Taurus.

October 14–18: Watch the crescent moon in the morning sky move past Mars, Regulus, Jupiter, and Saturn on successive days.

October 21–22: The Orionid meteor shower (up to 25 per hour) will be best during early morning hours on the 22nd.

October 28: Communities using Daylight Time set clocks back one hour to Standard Time.

October 29: Mercury is at greatest easterly elongation, ordinarily its best position for viewing in the evening sky, but the planet is poorly placed for viewing at this elongation.

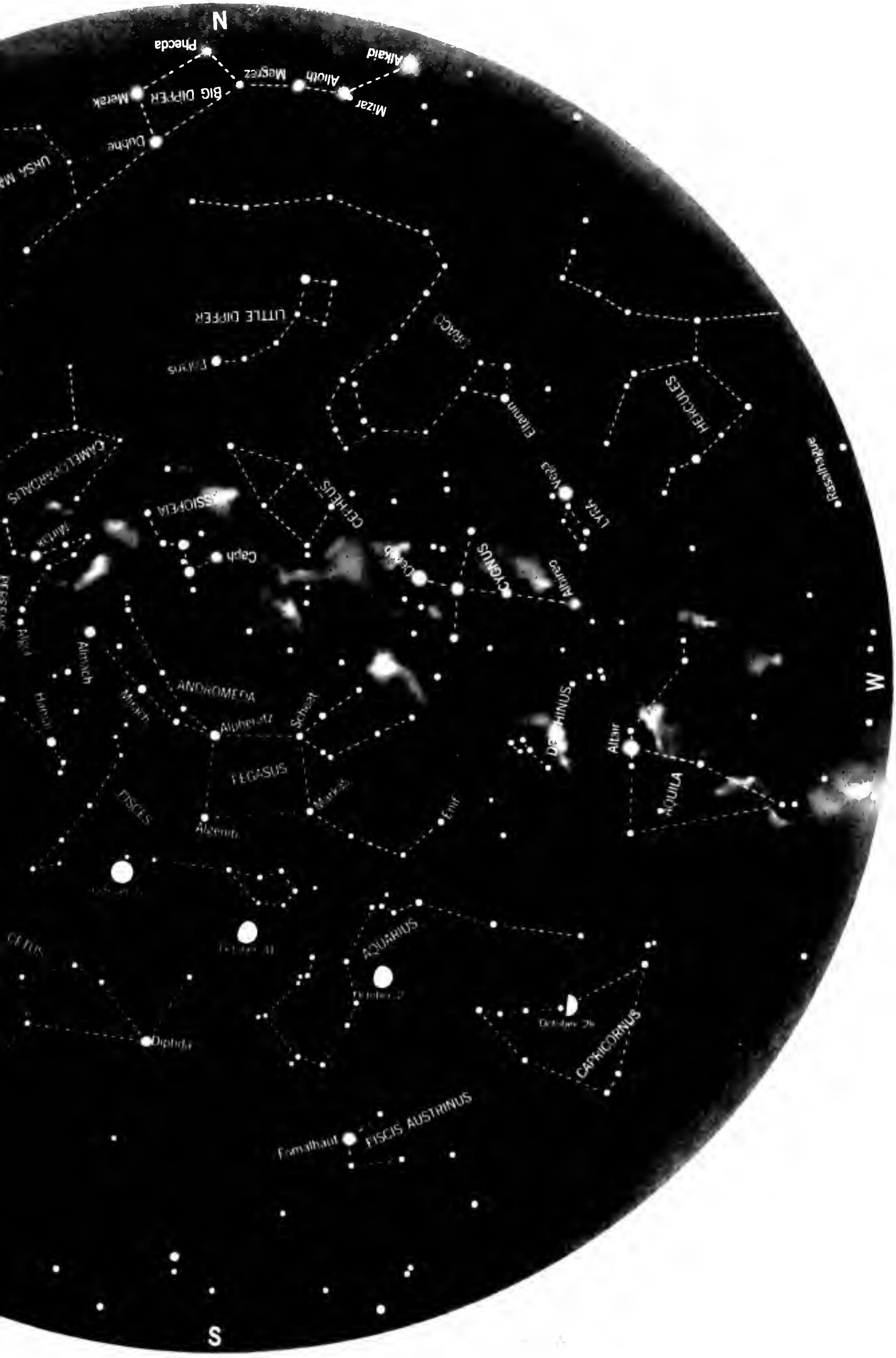
November 4: The full moon will minimize chances for seeing the Taurid meteors, which reach maximum this morning.

November 5–6: The bright star Aldebaran is covered by the moon for about an hour this evening (an occultation), shortly after midnight (EST, earlier in time zones to the west), throughout North America except in northern and western Canada.

November 9: Mercury is stationary among the stars and begins to move westerly (retrograde).

November 12–15: The waning crescent moon again moves past Mars, Regulus, Jupiter, and Saturn in the morning sky.

★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:15 P.M. on October 1; 10:20 P.M. on October 15; 9:20 P.M. on October 31; and 8:20 P.M. on November 15; but it can also be used for an hour before and after those times.



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Venus Observed

Even preliminary data from the Pioneer Venus *mission have led to some unexpected inferences about our neighboring planet*

by Richard Goody

A flawless spacecraft mission to Venus, designed to measure such parameters as temperatures, pressures, winds, cloud particles, and atmospheric constituents around the planet, took place early last December. The project embodied an integrated approach to a number of well-formulated problems whose solution, it was hoped, would contribute to a general understanding of the inner solar system, Earth included.

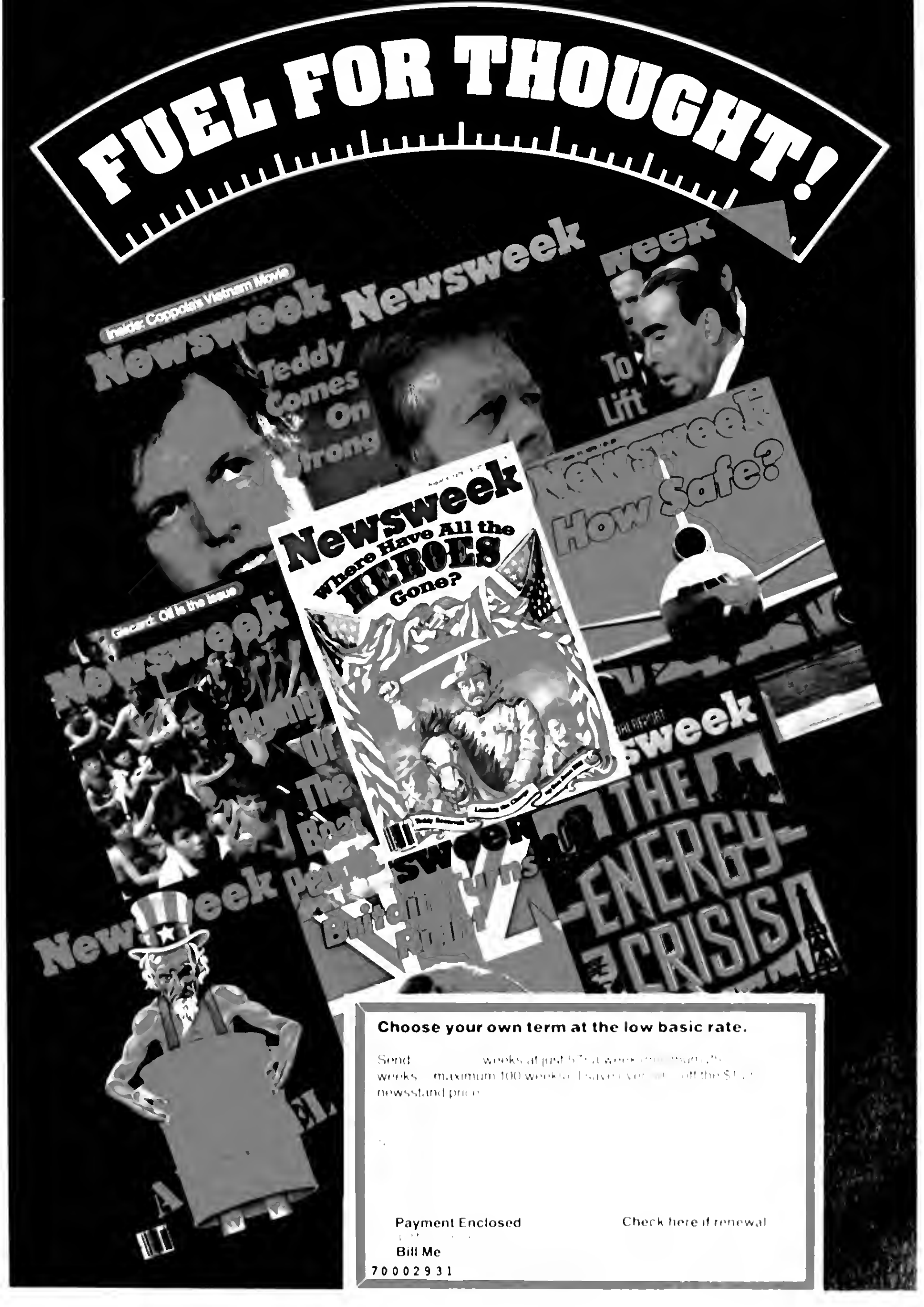
A year may pass before all the data are presented, properly interrelated, and shown to agree or disagree with existing theories. In the meanwhile a preview of the data has appeared in the February 23 issue of *Science*, the journal of the American Association for the Advancement of Science. I will report here on the current status of the information.

First, however, I would like to give my impression of the undertaking. When I arrived at the mission control center at the Ames Research Center in California on the seventh of December, *Pioneer Venus 1*—the orbiter spacecraft—had been in orbit around the planet for three days and was functioning perfectly; *Pioneer Venus 2*—the multiprobe spacecraft—was due to enter Venus's atmosphere on the 9th. The tricky process of bringing the orbiter's point of closest approach to the planet down from 125 to 95 miles was under way. This maneuver would allow the spacecraft to dip into an interesting region of the atmosphere where some important things happen.

Adjustment of the orbiter was crucial to investigation of the Venusian ionosphere, the planet's upper atmosphere, but it was not without hazard. The lower the closest approach, the greater the retarding atmospheric friction, incurring the possibility of orbital decay and loss of the mission. In fact, our early estimates of frictional loss proved to be on the high side and the lowering of the approach, by successive firings of retrorockets, was accomplished without difficulty.

At 10:00 A.M., local time, on the ninth of December five spacecraft were independently approaching Venus: Bus, the transport module to which the four probes from *Pioneer Venus 2* were attached, the Large Probe, and three small probes, named North, Day, and Night for the regions or times of their intended entry points. The Large Probe had been released from Bus on the sixteenth of November and the three small probes on the twentieth. All the probes had limited battery power and cruised without communication for nineteen days with internal instructions to switch on twenty-two minutes before entry into the planet's atmosphere. Mission controllers are accustomed to monitoring their charges day and night for problems, and this unusual procedure created the first of a series of anxious moments that followed each other remorselessly until the probes finally rested on the Venusian surface.

Unlike the probes, Bus possessed radio communications and was given a final trim early on the morning of the ninth. There was then nothing more to do but wait for the probes to switch themselves on and start transmitting at times between 10:24:26 (hours:minutes:seconds) for the Large Probe and 10:34:08 for the Night Probe. Approximately five minutes were allowed to link the probes to four receivers in Cal-



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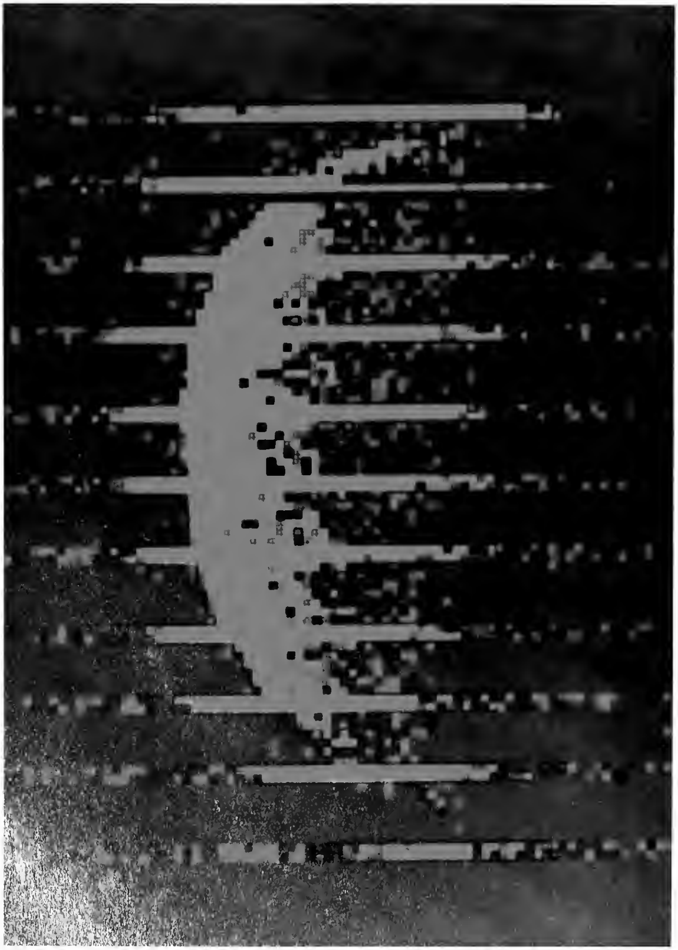

NASA

ifornia, Australia, Chile, and Guam where data would be collected. Of this five minutes, three were required for the signals to travel from Venus to Earth; the remaining two minutes were all that was left in which to discover whether the probes were still operating. Fortunately, they were. One at a time their signals were reported from the Deep Space Network at Goldstone, California, exactly as planned.

A brief grace period of about seventeen minutes followed, during which certain instrument functions could be checked out, before facing the next set of problems, namely, the loss of radio signals as the probes impacted and slowed down at altitudes of between forty and forty-five miles. Each of the four receiving stations had to rediscover all four probes, with the potential of failure at each step. Again, and in all subsequent events, the mission went faultlessly, a tribute to the engineers and designers from Ames Research Center and the Hughes Aircraft Company, who had worked for five years on the project.

After reacquiring the signals, the Large Probe was instructed first to deploy and later to jettison a parachute. This was to slow it down so that the same time (about fifty-five minutes) would elapse between entry into the atmosphere and touchdown on the surface for all the entry probes. Unexpectedly, the Day Probe operated for more than one hour on the Venusian surface. The probes were designed to work down to, but not *on*, the surface, and for three out of the four probes that is exactly what happened. The impact positions of the probes all went according to plan: the Large and Day probes entered in daylight; the other two on the planet's night side. The latitude spread was from 31°S to 60°N. The

Sunrise on Venus, top left, as seen from the Pioneer *orbiter spacecraft. This is how the planet might look in the early morning to the naked eye. The light and dark markings on the crescent Venus, top right, are computer enhanced. The image at left was made in the light emitted by oxygen and hydrogen atoms. The color represents brightness, not what the eye would see. Yellow denotes very bright; dark blue means no detectable emission.*

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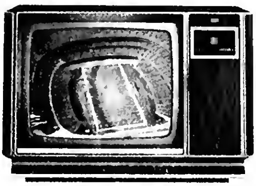

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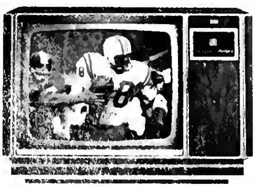

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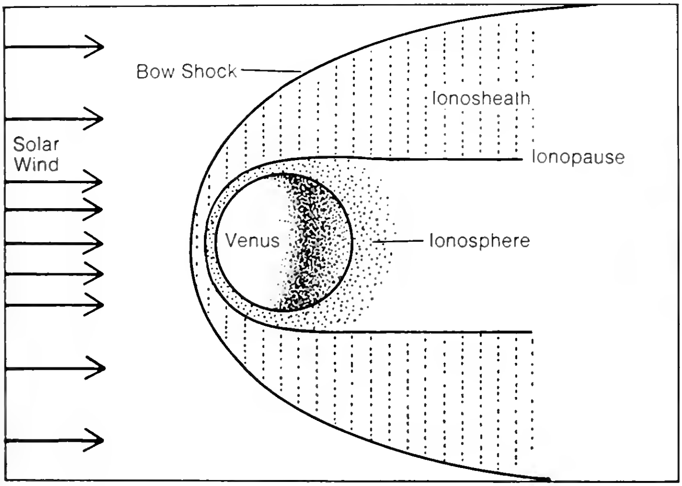

The solar wind forms a shock wave, called the bow shock, in front of Venus as it flows by the planet.

widest possible global range of latitudes was a desirable feature for the meteorological aspect of the mission.

While this intensive activity with the probes was under way, Bus pursued an independent course. It had no heat shield and burned up seventy miles above the ground after making measurements for a brief sixty-four seconds. The orbiter continued with its measurements down to the closest approach of ninety-five miles, as part of a planned sequence covering one complete rotation of the planet.

So much for the mission itself. Let me now try to put together an overall view of the preliminary conclusions from the numerous instruments on the orbiter and multiprobe spacecrafts.

While still far from Venus, spacecraft instruments measured the properties of the stream of charged, or ionized, particles flowing from the sun. This solar wind varies greatly with the state of the sun, so that its interaction with the planet was also expected to vary, and that turned out to be the case.

The first interaction between the solar wind and the planet is a shock wave called the bow shock, similar to that formed in front of a traveling bullet or supersonic airplane. The bow shock was found to be between 3,000 and 7,500 miles above Venus's surface, very much closer to the planet than the corresponding bow shock is to the earth. The general reason for this difference was understood before the mission, namely, that Earth's magnetic field holds off our bow shock, but Venus has only a very small planetary magnetic field, if any. Instead, a magnetic field is created by currents made to flow in Venus's ionized envelope (ionosphere) by virtue of the interaction with the solar wind.

The region between the bow shock and the start of the ionosphere (whose outer boundary is called the ionopause) is known as the ionosheath. The happenings in this region are complex but important for those who study the interactions of ionized gases. Data are now pouring in from a variety of instruments and should continue to do so for the 243 days of the nominal mission.

The ionopause is also subject to rapid changes as the solar wind changes. It has been reported between 50 and 1,300 miles above the planet's surface. The solar wind appears to flow around the ionopause as if around a blunt object, except for a small fraction of the wind, about 5 percent, which flows into and strongly influences the ionosphere.

The magnetic field induced in the ionosheath ceases at the ionopause as the ionization of the atmosphere increases. There is, in fact, a trade-off between the magnetic field and the ionization at the boundary; forces caused by the magnetic field are balanced by pressure forces in the ionized atmosphere, and this balance causes the boundary to be where it is.

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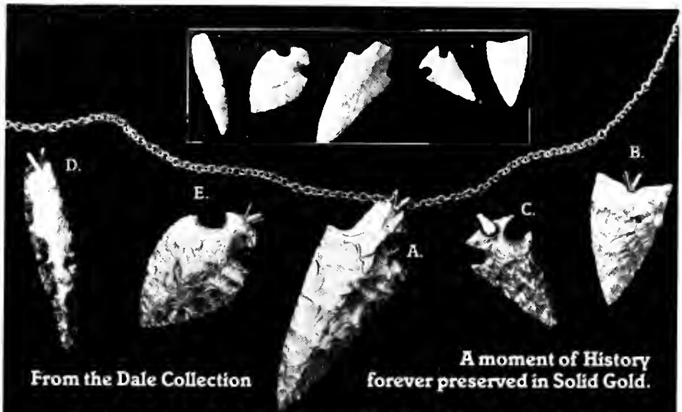

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From that point downward we are in the atmosphere proper. The ionization, that is, the density of electrical charge, increases to a minor plateau at 125 miles and to a sharp maximum at 90 miles. This trend, and particularly the position of the maximum, seemed to fly in the face of terrestrial experience and caused a spirited debate some years ago that did much to rejuvenate an important area of study. At the time of the mission, however, the only debatable questions were whether the plateau was caused by ionized *atoms* of hydrogen or of oxygen on the one hand or by ionized *molecules* of oxygen or of carbon dioxide on the other. The answer is now clear: atomic oxygen causes the plateau; molecular oxygen, the maximum. It remains for theorists to understand exactly why this is so and to assimilate a vast array of data on other charged and uncharged atoms and molecules of this region.

The temperature of the ionosphere turns out to be lower than all earlier estimates: 300°K on the day side, 100°K on the night side. Here again, there is some explaining to do, but one conclusion can immediately be drawn, namely, that this temperature, taken together with the measured concentration of hydrogen atoms at 110 miles, is too low to allow these atoms to evaporate rapidly from the planet out into space. "Rapidly" must be translated to mean "fast enough to allow the hydrogen from hypothesized amounts of primordial water to have left the planet during the age of the solar system."

One hundred and ten miles is the altitude from which the evaporation of hydrogen can take place. I discussed the reason we anticipate evaporation of hydrogen from Venus in "Oceans, Glaciers, and Mists," *Natural History*, October 1978. The basis for the argument is, however, challenged by argon isotope measurements from the *Pioneer Venus* mission, which I will discuss below. *Pioneer Venus* has therefore opened up a new chapter of inquiry related to the possible existence in a prior epoch of large quantities of water on the planet and where that water might be now.

Below the atmospheric region into which the orbiter spacecraft dips and in which Bus had its brief burst of activity is the region of the multiprobe spacecraft, an area where the data are of principal interest to meteorologists.

The most obvious single feature of this region is the cloud deck, ap-

parently unbroken at all times in all observable locations. We now have a wealth of data on the location of the cloud at four different places, its complicated structure with at least four layers, one over the other, the size of its drops, the chemistry of the atmosphere in which the drops form, and the fluxes of heat inward from the sun and flowing outward from the hot Venusian surface and lower atmosphere. Until this mass of data is understood in terms of plausible models it is impossible to describe it simply, and I shall therefore select only a few significant points.

The drop sizes carry a great deal of information. Small drops, probably consisting of sulfuric acid (see "Mission to Venus," *Natural History*, December 1978), are found in widely varying concentrations from one layer to the next between the cloud top at forty miles and the bottom at twenty miles. Below the latter level the atmosphere appears to be entirely free of dust or cloud particles. Larger particles appear in the middle of the cloud, and the possibility exists that we are observing a process akin to rain from a terrestrial cloud. If so, slow upward motions in the cloud are probably involved.

Our ideas about the clouds will be affected by a remarkable observation from the orbiter. The infrared radiometer—an instrument for measuring radiant energy—on that spacecraft reacts as if the cloud cover does not extend over all of the approximately ten degrees of latitude surrounding the planet's north pole. It is possible that there is no cloud at all in that region.

This observation suggests two partially independent and equally important matters. In "Mission to Venus" I emphasized the importance of the global meteorology and described the consensus that air would rise in the tropics and sink in a narrow region near the poles. Until now there has been no observational evidence for this view, but the marked difference in cloud structure at the north pole suggests that we are looking at that polar downdraft. The observation simultaneously suggests that motions play a role in the formation of the clouds and that an updraft is an essential feature of the process.

We might be further along in our understanding of the lower atmosphere of Venus had we known that the clouds were broken in polar regions, but celestial geometry was against us. Venus has almost no tilt to its rotation axis and unusual happenings near its poles have

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been outside our ability to make observations from the earth.

In the matter of cloud chemistry there now exists a set of important clues. There is a hint of yellow sulfur particles in the upper levels of the cloud. A number of gases are either abundant below the clouds and much less abundant above or vice versa, implying that they are destroyed or created in the clouds. Water vapor, some sulfur compounds, and oxygen are destroyed in the clouds and carbon monoxide is created. At this time we cannot describe with confidence the events that lead to cloud formation and dissipation except that they may have more parallels to a terrestrial smog than to stratus or cumulus, water or ice clouds. We are on the threshold of a deluge of chemical information that should leave the matter in no further doubt, once it is analyzed.

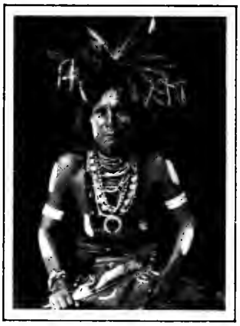
"Mission to Venus" described the *Pioneer* chemical experiments as "central to the Venus mission" and I have no reason to revise that opinion. A detailed understanding of its chemistry bears on many major questions about the planet. The clouds have been mentioned. The presence of water vapor below the clouds has many connotations. One is its possible relationship to the high surface temperature on Venus and the major difference between that planet and both Earth and Mars in this respect. The question is far from resolution, but the existence of a fraction of a percent of water vapor in the lower atmosphere of Venus now seems to be established and this is sufficient to play an important role in those thermal processes in the atmosphere close to the surface that maintain the planet's very high surface temperatures.

The chemical data revealed, even at first glance, an unexpected result with respect to two argon isotopes. Some background is, however, required before the significance of this result can be appreciated.

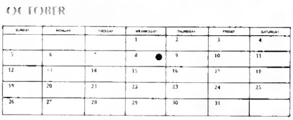
This background has to do with views about the formation of the solar system. We believe that the planets formed in a series of processes starting with condensation from a disk of ionized gas, or plasma, surrounding the sun and of the same general composition as the sun. Whatever the subsequent processes may have been, we consider them to be dominated by overall thermal and chemical conditions. For example, we expect to find a planet's interior made up of those heat-resistant substances that first condense as the primitive plasma cools. These should preserve their relative proportions through subsequent events. Other elements exist only as volatile gases (that is, the noble gases), which cannot condense at all in the inner solar system and must be collected by processes other than local condensation.

Independently of the precise processes, we anticipate similarity between certain groups of elements based upon their volatility. The most complex (and hence the most flexible) scenario so far proposed envisages six groups of elements whose internal proportions should be preserved throughout the inner solar system.

The Venus results are consistent with this picture to some extent, but there is one important discrepancy. We expect the ratio of the argon isotopes ^{36}Ar to ^{40}Ar to be the same for Venus as for the earth, but it is three hundred times greater. There can be no mistake. Mass spectroscopy is ideal for measuring isotopic ratios, and the *Pioneer* re-



A snake priest — Hopi



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sults are confirmed by measurements made by the Soviet Union's Venus landers, *Veneras 11* and *12*. Thus, instead of being able to use principles of similarity between chemical abundances as a guide to the formative processes of the solar system, we are led into an internal contradiction.

What does this imply? Nothing too serious, I suggest. The concordant features of Venus's chemistry confirm that we are reasoning in the right general direction. The argon results show that the path is wrong, but rethinking the problem will doubtless lead to a better answer.

One aspect of these events deserves a second thought. Without the Venus data we might have pursued indefinitely a false trail in our discussion of the earth's formation; a single measurement on another planet has forced us into a complete reassessment of the formative processes of our own planet.

In the hot, dense lower atmosphere of Venus the central questions concern the nature of the global winds, the way in which they transfer heat, and their influence on the temperature of the atmosphere. To put the issue in its simplest terms, without atmospheric motions Venus's poles should be extremely cold because they receive little sunlight. Instead, every measurement available before *Pioneer* showed almost no temperature difference between the equator and polar regions.

Many instruments on *Pioneer* were designed to throw light on the motions, temperatures, and heat balance of the Venusian atmosphere. Heat-balance measurements were made on the Large and Small probes but the clouds complicated the picture, and all of the data must be digested in a theoretical framework before we can say much about their relationship to the motions. I have mentioned the importance of motions to cloud formation. The clouds in turn affect the radiation balance, the atmospheric temperature, and the motions themselves. A similar relationship between many features of the terrestrial lower atmosphere makes climate prediction on the earth an extremely difficult task, and we cannot fail to learn something useful about our own climate from understanding Venus better.

At this time we have only limited results concerning Venusian meteorology. The temperature differences between widely separated regions are, as expected, very small—so small that careful calibration and reduction will be required to sort out the differences.

A second preliminary result about atmospheric temperatures seems to indicate an important difference from the earlier *Venera* results. The decrease of temperature with height above the surface may be slightly slower than that expected from simple thermal convection from the hot surface. *Venera* measurements suggested that the expected decrease did occur, meaning that substantial amounts of heat could be transferred upward from the surface by this convective process. If the decrease is less than presumed, as *Pioneer* results suggest, convective heat transport will be negligible and the global winds must then be responsible for the upward transport of heat, as well as that from the equator to the poles. To the layman this may not be a spectacular discovery, but for the meteorologist it is an observation that revolutionizes the accepted view of the way the atmosphere functions.

I have already mentioned the gap in the clouds at the north pole, indicating a rapid downward flow of air. What we need now is the complete global wind field and this we should obtain from the radar tracking of the probes. The data are, however, still in the computer. The tracking results were recorded in Chile, Australia, Guam, and California, and the tapes were shipped by air to MIT where the long and complex task of analysis will take place. We know that the results are good. The data are complete and their quality has been tested. An accuracy of about one mile per hour in the wind velocities at all locations seems attainable, and some features, such as the velocity component in the direction of the earth, will be far more accurate.

The fortuitous survival of the Day Probe on the Venusian surface for an hour has greatly enhanced the quality of this work. Probe positions must be related to a reference point since the radar-tracking technique is only capable of measuring relative positions. We now have such a point, which we could not have anticipated, fixed solidly on the Venusian surface.

Finally, what have we learned about the solid planet and its surface? The orbiter spacecraft should eventually establish Venus's intrinsic magnetic field or a low upper limit to it, and this is important for our views about the planet's core. For this we must wait for the orbit to precess until the point of closest approach is away from the sun and conditions are less disturbed by the solar wind.

The orbiter will also establish the gravitational field and its anomalies, as Earth orbiters have done for our own planet. Such studies can help us understand Venus's crust and mantle, but the data collection will take a long time to complete.

The chemical results, already discussed, are important for our understanding of the crust, and the high surface temperatures and pressures insure a close connection between the chemistry of the surface and that of the atmosphere.

The one instrument capable of direct measurement of the surface is the radio altimeter on the orbiter. Eventually, when the orbiter has precessed around the planet, this instrument will yield maps of altitude and of other surface properties over the entire globe. The resolution, or ability to separate features, is no better than that obtained from ground-based radiotelescopes in those limited regions of Venus accessible from the earth, but the complete coverage afforded by the orbiter will be a great step forward.

Tidbits of information are becoming available. The experimenters have tentatively announced the existence of a trench, more than 620 miles long, whose bottom in some places lies about three miles below its rim. If this discovery is confirmed by subsequent analysis, it will be difficult to avoid the conclusion that this feature has been caused by an extension of the crust, in a way that may be analogous to the formation on Earth of the eastern African Rift Valley.

There is not much more to say about the *Pioneer Venus* mission at this early stage. The slow pace of analysis may surprise the reader who is accustomed to "instant science" performed before television cameras. Most previous space missions have been of an exploratory nature, made in the hope of finding the unexpected. *Pioneer Venus* had a different motivation. We were, in the main, looking for explanations of known phenomena and the mission was designed with interrelated instruments directed toward common groups of problems. Until the data are understood as a whole, conclusions are uncertain, and a great deal of work will be required before the mission's scientific objectives are realized.

Richard Goody is Mallinckrodt Professor of planetary physics at Harvard University. He was an investigator on the Pioneer Venus *mission.*

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Letters

Old Abe Lives On

In concluding the story of the live bald eagle carried through the Civil War by the Eighth Wisconsin Volunteer Infantry ("The Glorious Bird," June–July), I suggested that the great bird was still remembered.

Just how well remembered Old Abe is I have subsequently learned from interested readers. A letter from Oregon reports that a tour guide at the Vicksburg battlefield points out the perch on which Abe sat during that battle and my correspondent added that the guide said the defenders "would rather have shot that bird than General Grant."

The 101st Airborne Division at Fort Campbell, Kentucky, descends by direct military genealogy from the Wisconsin regiment, and its 18,000 men are known as Screaming Eagles, while the annual celebration of the formation of the Division is known as Week of the Eagles. The letter column of the *Fort Campbell Courier* is headed "Dear Old Abe" and the memorial to the 101st's dead in Arlington National Cemetery includes a marble eagle with wings outspread.

The huge 50- by 400-foot cyclorama at Atlanta, Georgia, depicting the Civil War struggle for the city, shows Old Abe soaring over the din and smoke of battle, but Professor James Harvey Young of Emory University points out that the Eighth Wisconsin was never near Atlanta. All becomes clear, however, when one learns that the scene was painted in Milwaukee, Wisconsin—by eagle loyalists!

Gerald Carson
Millerton, New York

Dinner Conversation

I thought that Milton Love's "Guests and Hosts" (June–July) was in abominable taste. A Seder is not a "ceremonial dinner" or an "occasion for conversation"; it is a religious service conducted in the home. One

who does not respect Jewish traditions, and who spends the Passover evening in a stupor waiting for brilliant repartee, has no business participating in a Seder.

Stanley L. Weinberg
Ottumwa, Iowa

I was delighted to read Milton Love's "Guests and Hosts." He has described a rather common event for us practicing parasitologists. His unique description of his audience's reactions to his persistent detailing of each parasite's habits was fantastic. Such examples of well-done humor and satire in our field are far and few between.

Dr. Dickson D. Despommier
Associate Professor of Health (Parasitology), Columbia University, New York, New York

A Bite of the Tongue

Raymond Sokolov's article "Lickerish Delights," in your June–July issue, lived up to its title. However, *Pfeffernüsse* ("pepper nuts") are ball-shaped, dusted with confectioner's sugar, and flavored with cinnamon, cloves, and/or other spices that bite the tongue. They have *nothing* in common with anise-flavored, flat, square, embossed, "brittle white" *Springerle*. The rumblings you hear 180 miles southwest of New York are from my late grandfather, a German-born baker who baked many thousands of *Pfeffernüsse* and *Springerle*, turning over in his Baltimore grave.

Louise N. Worrell
Bethesda, Maryland

ERRATUM: The Star Map in our August–September issue was accidentally reversed, causing the constellations to be in the wrong places and the Milky Way to stretch in the wrong direction. Our apologies to all star gazers who wonder what happened to the universe.

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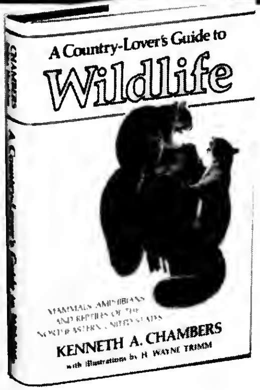

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Lecturer in Zoology, American Museum of Natural History
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Kenneth Chambers lectures on wildlife for the American Museum of Natural History in New York City and has led field study tours to wilderness areas all over North America. H. Wayne Trimm is art director for the *Conservationist.* $14.95

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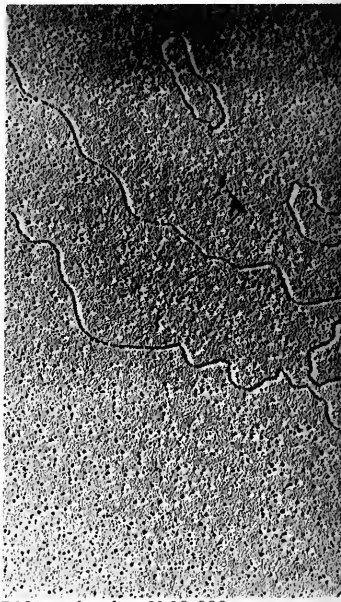
The discovery of the structure of the DNA molecule was a unique event in the history of biology, and this book, which takes us from the origins of the discovery into its wider ramifications, is a unique book. From time to time a reviewer will be given a book of such magisterial proportions and quality that it almost defies analysis and criti-

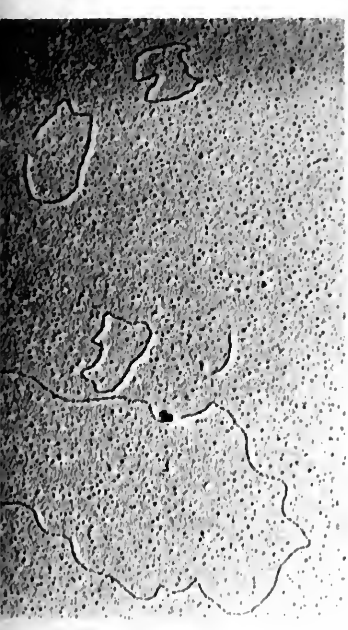


DNA molecules, X 30,000

by June Goodfield

cism. *The Eighth Day of Creation* is such a work, a product of unrivaled devotion to a topic, where scholarship is happily wedded to literary skills.

Horace Freeland Judson was the European arts and science correspondent of *Time* magazine. Clearly, the discovery of the structure of the gene triggered a consuming passion to record the circumstances leading to and following that discovery, before the people and the documents disappeared into the bland perspective of history.



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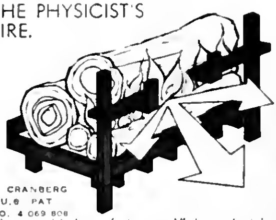

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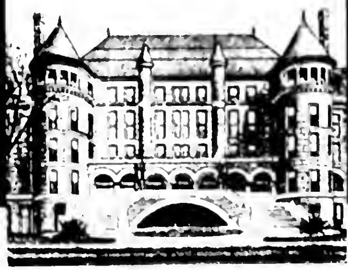

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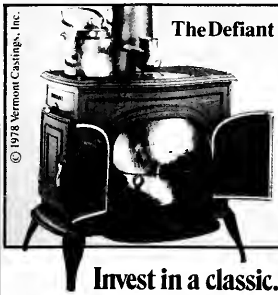

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What the author has done is to present us not only with a superb account of the development of the ideas and discoveries before and after the model was first proposed and with the competing, and often conflicting, visions and concepts of the scientists concerned, but he has also set all this against two essential backgrounds often ignored by historians of science: the social matrix against which the ideas evolved and the vivid, delightful (and sometimes exceedingly unappealing) personalities of the scientists involved.

The structure of the gene—that is, the nature of DNA—was bound to be a tremendous challenge to scientists, for whatever this structure turned out to be, the model for it would need to be a compelling one. This is because the genetic material, which runs through biological life like a fine, unambiguous thread, has two apparently contradictory properties. At one and the same time, it has to be stable enough so that the continuity of life forms can persist but unstable enough to allow for those very necessary qualities of variation without which the evolution of organic life would not be possible. In addition, the genetic material has to contain within itself an obvious mechanism for self-replication by simple division in such a way that its total quantity is restored again in the daughter cells.

The model that Crick and Watson (if you are British) or Watson and Crick (if you are American) proposed fulfilled these requirements splendidly, although it is apparent from this book that acceptance of the model was by no means universal or immediate. There are almost no instances in the history of science where new discoveries are warmly embraced in their entirety, however much we might like to think that the truth of a genuine discovery must be clearly self-evident. But, as is well known by now, once the model was finally accepted, it triggered a tidal surge of research into the finer details of the molecular biology of cells, which is beautifully recorded and analyzed here.

Dr. James Watson in *The Double Helix* gave his own personal, somewhat waspish account of his role in that discovery and his perceived role of others. Although it whetted the appetite, the book's tone, obvious inaccuracies, and unkindnesses were a warning against relying too much upon it as an account of genuine history. But by then enough was known to realize that the

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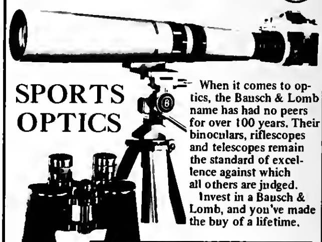

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discovery had precipitated a classic conflict between two of the protagonists that must rank as one of the most famous quarrels in the history of science: a questionable episode in which a photograph that belonged to one scientist, Dr. Rosalind Franklin, was shown to a second, Dr. James Watson, by a third, Dr. Maurice Wilkins, who was acting with motives that will never be entirely known. Watson touched on some of this, but it is Judson who, in the first third of this book, tells the entire story. One feels for the very first time that the historical truth is out at last and that the unhappy ghost of Rosalind Franklin can finally rest, for her formidable role in this story is at last truthfully exposed.

As I read this first section I was caught up in much more than the mere excitement of discovery, for things I had never known before about the episode are revealed—comments, inferences, experiments, anecdotes, arguments, and attitudes that at times come as a surprise. For example, it brought me up sharply to learn that Watson, whose best seller brought him wide personal fame, not to mention a lot of money, could nevertheless write to his colleague Crick in the following terms, objecting to the very innocent suggestion that he, Crick, should give a talk about the discovery on the BBC's "Third Programme."

> I still think a talk on the 3rd (Programme) would be in bad taste. There are still those who think we pirated data and I am of the belief that a few enemies are worse than a few admirers. Judging it on a monetary basis ($100) seems unfortunate. Basically, however, you are the one to suffer most from your attempts at self-publicity. My main concern is not to be dragged into it. If you need the money that bad, go ahead. Needless to say I shall not think any higher of you and shall have good reason to avoid any further collaboration with you.

In the knowledge of what Watson went on to publish and of Crick's well-known refusal to grant interviews, that paragraph is unbelievable, and it is a measure of Francis Crick's forgiving nature that he could finally bring himself to speak to Watson again.

The remaining two-thirds of the book takes the story into the mid-1970s, and in remarkable detail—of persons, events, facts, meetings, theories, arguments, and scientific papers. There are many perceptive comments on many aspects of science. For example, on discovery and the acceptance of scientific ideas: "Extreme

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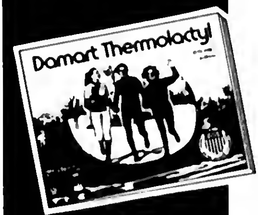

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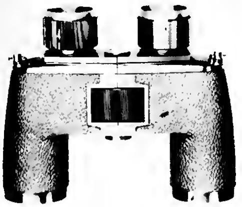

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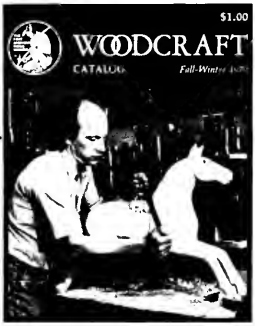

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elegance is more convincing than it should be." And on the difficult task of the historian of science: "Confronted with this living fabric . . . the historian picks up his shears, hesitates, and puts them down again. Whatever he does he will be like the damned eighteenth-century Dutchman who made Rembrandt's *Night Watch* smaller to fit a smaller room."

In reconstructing the totality of this canvas the author had several strokes of good fortune: Jacques Monod's comments, which caused Judson to change the pattern of his proposed book; the correspondence between Francis Crick and Sydney Brenner, which "provided a month to month account of the science of molecular biology as Crick saw it grow"; and his own imaginative empathy, which can encapsulate situations and people in the most charming of phrases. It is clear that Crick and Monod are the two heroes of this section, and I for one applaud this selection. It was these two biologists above all who provided the ever expanding theoretical thrusts of contemporary molecular biology, and they are skillfully portrayed as the giants of science that they undoubtedly are (Monod died a few years ago).

But there are minor irritations and some major faults within this book, which demands far too much from the reader. No concessions are made to those who are scientifically illiterate and not many to those who are scientifically literate. To follow the theoretical ramifications and empirical detail of the work is extremely difficult and is not aided by the author's lack of self-discipline when it came to editing his own *magnum opus*. Judson's own compelling internal need to do this work is very obvious, but at times one wonders whether he was writing as much for himself as for any audience. There is an abundance of unnecessary and journalistically unprofessional repetition. It is as if Judson, free at last from the extremely limiting space constraints of a reporter for *Time*, went to the other extreme and allowed himself the luxury of saying everything that he wished to say.

But an editorial hand is badly needed. For example, near the beginning and again near the end, Max Perutz is made to describe the differences between his problem—solving the structure of a protein molecule—and that of solving the structure of DNA, and does so in practically identical sentences in both places. Yet

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again, the author's desire to cover as much as possible of nineteenth-century and twentieth-century history leads to long interruptions of his train of thought—for instance, the story of Perutz's preoccupation with hemoglobin, which began in 1937 and many years later led to his analysis of the structure of the molecule and finally the Nobel Prize, is broken into near the beginning by five closely packed pages on the history of this blood pigment. These are not the only examples; many times a fact triggers a thought in the author's mind and off he goes into its development, returning to the original line many pages later. It is too much, even for the most diligent reader.

There is also one surprising omission, although without knowing in precise detail the timetable of this writing, it may be unfair to bring it up. Nevertheless, the glorious science of molecular biology, which the author develops so skillfully for us, was itself momentarily halted in 1972 by the Asilomar Conference. For the issue of recombinant DNA, a natural technical development from the earlier science of molecular biology, raised in scientists' minds—and ultimately in those of the general public—the possibility that certain experiments might be risky, if not generally dangerous. Thus recombinant DNA proved to be the occasion when the nature of the social contract between the scientific profession and society at large came up for reexamination and renegotiation.

Unexpected, certainly unanticipated, the advent of recombinant DNA was a unique event in the history of biology in more ways than one, and it is surprising that nowhere in this book is it mentioned. It is even more surprising because Sydney Brenner—one of Judson's main characters and one of the very few scientists with a deep appreciation of the new political dimension that had entered molecular biology—took a leading role in the discussion over the technique. There is thus a sad paradox to the history at this point, for the success of the science precipitated a reassessment of biology—and this is surely worth a mention.

June Goodfield is adjunct professor at Rockefeller University. She is the author of Playing God *(Random House and Colophon Books) and* The Siege of Cancer *(Random House and Dell paperback).*

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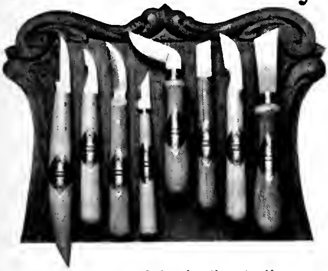

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Gestures

The hands may be as eloquent as the tongue

by Desmond Morris

The importance of human gestures has been greatly underestimated. Students of linguistics are everywhere, and the analysis of human languages is a widely accepted scientific subject, but the gesture specialist is a rare bird indeed—not so much a vanishing species, as one that has hardly begun to evolve.

There are two reasons for this. In the first place, gestures have quite wrongly been considered a trivial, second-class form of human communication. Because verbal exchanges are man's crowning glory, all other forms of contact are viewed as somehow inferior and primitive. Yet social intercourse depends heavily on the actions, postures, movements, and expressions of the talking bodies. Where communication of changing moods and emotional states is concerned, we would go so far as to claim that gestural information is even more important than verbal. Words are good for facts and for ideas, but without gestures, human social life would be a cold and mechanical process.

If this is so, then why has the science of gestures lagged so far behind the science of linguistics? The second factor working against such studies is a curious one and is difficult to express. It is as if, by their very nature, gestures

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do not like being written about. They resist verbal analysis. On reflection, this is not so surprising. Gestures provide a nonverbal channel of communication, and attempts to verbalize them are bound to meet with a special set of problems.

We use hundreds of expressive movements every day as we pass through the social events that engulf us from waking to sleeping. Each of these actions has a particular history—sometimes personal, sometimes cultural, and sometimes more deeply biological. By tracing the antiquity and the geographical range of these actions we can begin to see them more clearly as an understandable pattern of human behavior.

For the American reader, the gestures discussed here have a special interest. Most of them were already in common use in Europe when Columbus set sail on his voyage of discovery. Over the centuries, as wave after wave of Europeans crossed the Atlantic to take up residence in the New World, the American gesture repertoire has been repeatedly enriched. One European culture after another has transported its symbolic gestures and incorporated them into the body language of modern America. Traveling around the United States today it is possible to observe here a Roman insult, there a French compliment, a Sicilian threat, or a Scandinavian greeting. Usually their origins have been forgotten—they have been absorbed and integrated, a part of the American cultural scene. So to study European gestures is to study the roots of American gestural communication.

The Fingers Cross

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"common superstition." Viewed in this way, the act of crossing the fingers was originally a cryptic version of making the sign of the Christian cross. Instead of crossing himself openly in the usual way, a Christian could protect himself from the powers of evil by making a "cross" with his fingers, an action small enough to be easily concealed from unwelcome eyes. Assuming this interpretation is correct, the belief of the gesturer would be that the presence of the powerful holy cross would ward off evil or hostile influences. Such protection would be called upon if the gesturer was facing some kind of risk and felt the need of God's aid or if he was behaving badly in some way—telling a lie, for instance—and wanted to protect himself from retribution.

Since crossing the fingers did not look overtly cruciform, it is easy to see how it could drift away from its sacred role and become a simple piece of folklore, more repeated than understood. Eventually, its origins obscured, it could then come out into the open as a light-hearted social gesture, performed by Christians and non-Christians alike.

The Nose Thumb

Although it is known to more Europeans than any other symbolic gesture we studied, the origins of thumbing a nose remain puzzling. Why the act of holding the hand up to the nose in this particular posture should be so universally insulting is not at all clear. The clues are vague and often conflicting. Even the antiquity of the gesture is uncertain.

It has been suggested to us by an informant in Germany that the gesture may have originated specifically as a jester's signal. It seems that a medieval

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jester named Till Eulenspiegel traveled through Germany taunting and mocking the locals as part of his act, and he is said to have employed the nose thumb gesture as one of his main insults, making it popular over a wide area. Whether or not this is true, it would appear that by the sixteenth century the gesture had become associated with fools and jesters in a context of light-hearted teasing.

The Hand Purse

The hand purse is a multimessage gesture. Many gestures have more than one meaning, but it is unusual to find one with such a variety of meanings, even over a wide range of territory. The explanation lies in the primary source of the hand purse, as a "baton signal."

Baton actions occur when the hands "beat time" to spoken words. When a speaker emphasizes his words in this way, he uses a variety of hand postures, depending on the mood of his

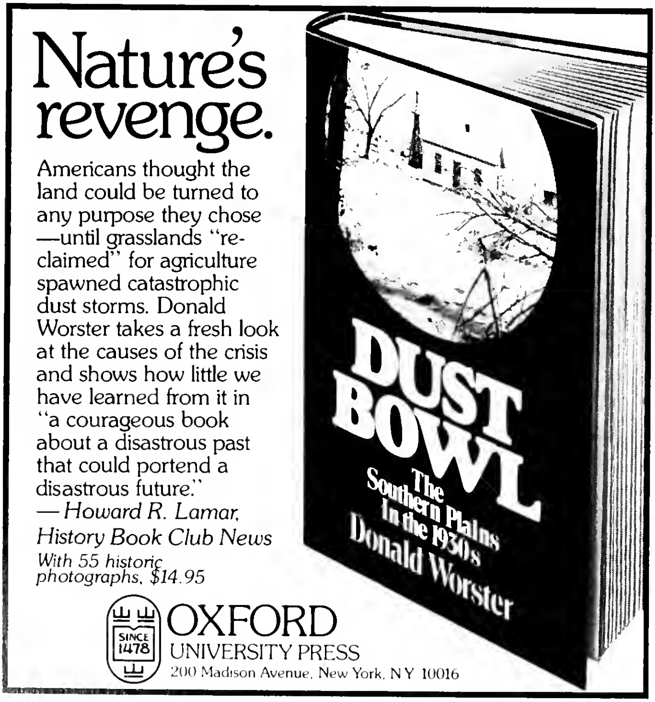
statements. If he is making a fine point or requesting greater precision or clarity, he is likely to display the typical "precision grip" so characteristic of the human species, namely the bringing together of the tips of the digits as if holding some very small object. The original precision message is capable of a variety of special extensions, evolving separately as distinct local traditions. In one region, the primary signal of "precise emphasis" has changed into "please be more precise" or "what are you trying to say?" In this way, it can become a gestural equivalent of a question mark. It can either accompany a spoken query or act as a substitute for it. When performed silently, the gesturer simply purses his hand at his companion, who infers from the context why he is being questioned and answers accordingly. From the basic statement of precise emphasis, the message has become transformed into "this thing has precision." From there it has changed to "this has class," to "high quality," to "excellent," to "good." So, although the hand purse may be a query, often an irritable one, in one region, it can also be a satisfied or excited signal of excellence in another.

To confuse matters further, in a third region the gesture implies strong criticism or sarcasm, while in yet another region, the hand purse message "be precise" has become "be careful." From there it has changed to "take it slowly." In certain areas, the gesture also means "lots." It might be "lots of people" or "a crowd" or it might simply mean "many," "plenty," or "much." The symbolic root here is the bringing together of all the fingers in a clump or cluster—the combining of individual units into a tight group.

The Forearm Jerk

The forearm jerk is a phallic gesture. The forearm with its clenched fist represents a supernormal phallus and its jerking movement imitates the thrusting of the penis. The gesture is most often seen in male groups, with one man using it to insult another.

If titles can be used as a guide, it seems possible that the forearm jerk developed first in the French-speaking world, because it is there that it has been given a special name. For the British and the Italians, it has no name, but almost every Frenchman knows it as the *bras d'honneur*, literally, the "arm of honor." This equates male honor with male virility, but it is a



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curiously old-fashioned term, which suggests that it has been in use over a long period. Were this not the case, it would be rather strange for a title relating to honor to be used in modern times for a gesture that is, by common knowledge, a gross obscenity. But the exact date of its beginnings remains a mystery.

Today, in addition to its role as a sexual insult, the forearm jerk also appears as a vulgarly complimentary sexual comment. In some countries this has become the dominant theme for the gesture, and it is employed as a signal that a male feels sexually aroused by a particular female.

The Nose Tap

The gesture appears to have originated as a "sniffing out" signal. By tapping the nose we remind our companions that we can smell out trouble or that someone can sniff us out. From this simple starting point, the gesture has taken off in six slightly different directions in different regions.

1. The nose tap as a sign of complicity. The message is "It's a secret."
2. The nose tap as a friendly warning: "Be alert!"
3. The nose tap as an accusation of interference. Here the nosy person is the direct recipient of the gesture, and the message becomes "Mind your own business."
4. The nose tap as a sign that the gesturer is alert.
5. The nose tap as a way of praising cleverness. In this case the message becomes "He is very bright," meaning that he is good at sniffing out the truth.
6. The nose tap as a threat. This is a special way of saying "I am alert." The message becomes "I know what you are up to, and if you don't stop it, I will attack you."

Clearly, all six of these meanings are closely related to one another, and it is tempting to lump them together under the general heading of "alertness." But if they are separated in the way we have suggested, then gesture-mapping of the different versions reveals local biases. This then serves to illustrate the way in which a simple, basic action, such as touching the nose, can begin to lead off into a slightly different symbolic role in each region.

The Palm-back V-Sign

Although the dominant meaning for this gesture is "victory," we want to consider first its role as an obscene insult. This is the older meaning, and its origin has been the subject of much debate. The obscene interpretation of the palm-back V-sign is confined almost entirely to the British Isles, where it is known to virtually the entire popu-

lation. So we are faced with the rare occurrence of a gesture unique to British culture. Why it should have failed to travel and spread its range is not entirely clear, but we can offer a partial explanation.

Outside the English-speaking region of Europe, the role of the "insult V" is taken over by the forearm jerk. In the British Isles, this usage of the forearm jerk is not common. Instead, it is used as a vulgar sexual compliment. In other words, the rest of Europe has a perfectly good obscene jerk of its own—the gestural niche is filled—and does not need ours to add to its repertoire.

Leaving the insulting version of the palm-back gesture, we must briefly consider its other usages. Since it is not known as an obscenity outside the British Isles, it is available for other interpretations. Almost everywhere it is commonly mistaken for the Churchillian victory sign. Non-English speaking communities make no distinction between the palm-front and the palm-back forms of the gesture. They see both versions as meaning the same thing: victory or peace. □

Right Show-jumper Harvey Smith making his V-sign gesture at the Hickstead meeting, as seen on British television. He is clearly using the palm-back version of the gesture. *Above* Harvey Smith recently used the sign to advertise Victory-V lozenges, but now the hand position has been reversed

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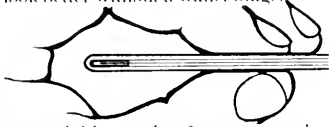

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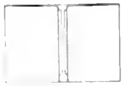

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At the Museum

Our large brains and upright posture are perhaps the two characteristics that best distinguish us from other primates. The emergence of these peculiar human traits must therefore figure prominently in any theory of human evolution.

One theory, which prevailed until recently, suggests that brain enlargement and bipedalism evolved together (the "positive feedback" model). As our posture became more erect, our hands were freed for toolmaking and our brains grew larger to exploit our toolmaking ability.

The discovery in Tanzania and Ethiopia of three- to four-million-year-old human footprints, together with the fossil remains of sixty relatively small-brained but fully bipedal hominids, has prompted some scientists to advance a new theory on the origin of erect posture. They believe that bipedalism occurred well before brain enlargement, perhaps in response to one partner's need to carry food to the other. As the period of infant dependency increased, ancestral females had to care for more than one infant at a time. For the species to survive, a bond had to develop between the father and the family so that the father could bring back meat from the hunt, while the mother gathered vegetable food and cared for the children. A new social system arose, which resulted in a close, nuclear family, increased bipedalism, sex for "pleasure," and increased variability in facial features so that partners could recognize one another. All this occurred, the theory suggests, without necessarily involving brain enlargement.

These conflicting theories of human origin are now being hotly debated. The Department of Education of the American Museum of Natural History, in cooperation with the Foundation for Research into the Origin of Man, is sponsoring a symposium on "New Evidence of Human Origins." Three scientists who have been near the heart of the debate—Eric Delson (associate professor of anthropology, Lehman College, and research associate at the Museum), Timothy White (assistant professor of anthropology, University of California, Berkeley), and Clifford Jolly (professor of anthropology, New York University)—will discuss human origins using slides and film. After the discussion, the floor will be opened to questions from the audience.

Symposium on "New Evidence of Human Origins" October 24, 7:30 to 9:00 P.M. Tickets are $6.00. For further information, call weekdays (212) 873-1300, extension 566 or 559.

The fall exhibition program is well under way. The following temporary exhibitions are currently on display or due to open shortly in the Museum and Hayden Planetarium:

• **The Art of Scientific Illustration** Akeley Gallery. Through November 26. The artistic eye is said to be very different from, and even opposed to, the scientific eye. In viewing this exhibit, however, one is reminded that many great artists—Leonardo da Vinci and Albrecht Dürer are just two examples—carefully studied natural history subjects. The works of thirty contemporary illustrators are displayed, as well as a selection of historical illustrations from 1800 to 1920. The subjects range from fantastically intricate renditions of insects and delicate flowers to four-color medical drawings. Although they were created for scientific purposes, the illustrations can be enjoyed on a purely aesthetic level. This exhibition, enriched by works from the Museum's collection, is on loan from the Smithsonian Institution Traveling Exhibition Service.

• **Huichol Indian Art** Gallery 77. November 7 through February 10. In "The Art of Being Huichol," which

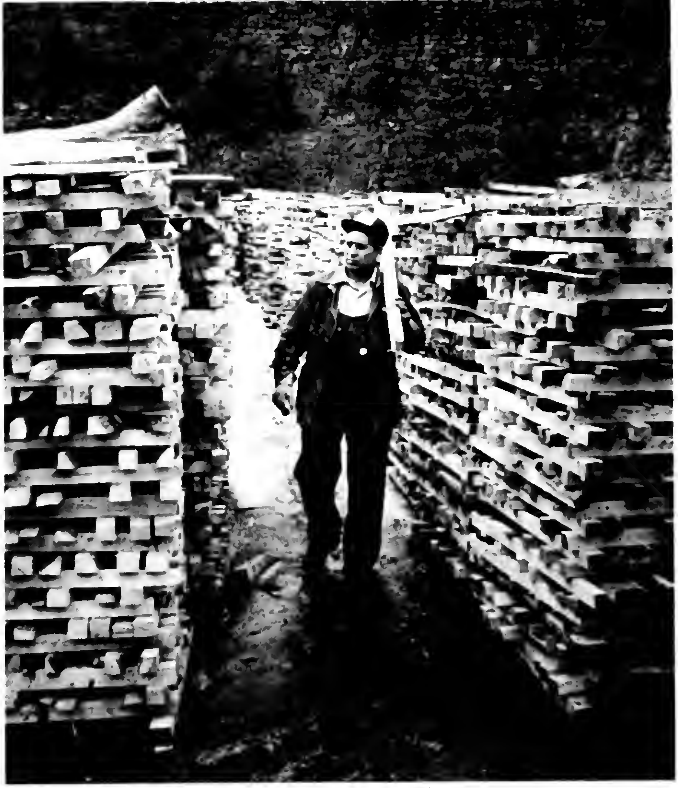
AMNH

begins on page 68, Kathleen Berrin describes her experiences in creating this exhibition.

- **Museum Photography** Exhibit Area of the Rare Book Room. Opens early October. While photographing natural history, many early museum photographers also trained their cameras on each other. The staff of the Photographic Collection has assembled interesting black-and-white examples of early photography from the Museum's vast collection.
- **Building Stones** Roosevelt Rotunda. Through October. Builders select stones for their durability and beauty; Sidney Horenstein, scientific assistant in the Department of Invertebrates and the creator of this exhibit, selects building stones for their scientific interest. His samples of building stones from all over the world show sectioned and polished fossils, crystalline structures, and other features revealed by the stonecutter's craft. The scientist—and the visitor—can read the history of the stones' formation on the polished surfaces of many of New York's buildings.
- **1979 Natural History Photographic Competition** Center Gallery. A display of prizewinning photographs as featured in the August–September issue of *Natural History*.
- **Images of Earth from Space** Hayden Planetarium. Through December 16. Sometimes, scientific photography produces images of striking abstract beauty. This is the case with many of the Landsat pictures taken of the earth from low earth orbit. NASA's computers assembled the images, often in surrealistic colors, from data collected by multispectral scanners aboard the satellites. This exhibition, on loan from the Smithsonian Institution Traveling Exhibition Service, also includes photographs taken by astronauts (see "Looking Down at Everest," p. 126)

Colony in Space Hayden Planetarium Sky Show. Through November 19.

Perhaps in this century, people will begin to live—to be born and to die—



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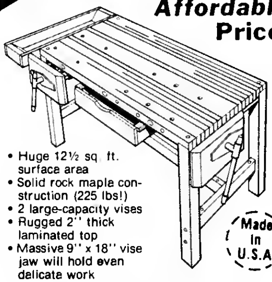

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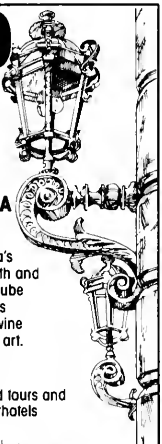

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off the planet Earth. Written by Mark R. Chartrand III, chairman of the Planetarium, the Sky Show is based on the latest research on how humankind may first colonize extraterrestrial environments.

Discovery Tours

Unusual and exciting trips to exotic places are presented by the Museum's Discovery Tours. All trips are led by Museum scientists and associates. Thomas D. Nicholson and François Vuilleumier will lead a cruise around the British Isles aboard the 353-foot m.t.s. *Orpheus* next year from July 2 to 16. Nicholson, an astronomer and director of the Museum, and Vuilleumier, an ornithologist, will be joined by a botanist, a classical historian, an archeologist, and an art historian.

The early part of the tour will include Canterbury, Hadrian's Wall, and Edinburgh, followed by island-hopping through the Shetlands, the Orkneys, and the Hebrides. The cruise, with lectures in between stops, will then thread its way through the Sound of Sleat and into Sligo Bay, where passengers will have the opportunity to disembark and visit the lakes of three Irish counties. The trip will conclude with a visit to Tresco and Guernsey. Prices range from $2,500 to $3,800, plus air fare.

Other Discovery Tours will take the adventurous to such places as the Red Sea (aboard the m.t.s. *Orion*), New Zealand, Mongolia, and the Galápagos. For more information, write to Discovery Tours at the Museum.

Courses and Workshops

Most lectures, courses, and workshops begin in the middle of October, so prompt registration is advised. For more information, call (212) 873-7507 or write to the Department of Education at the Museum.

Fall 1979 Evening Lecture Series includes Ancient Mayan Cities; Central Park: New York's Remarkable Backyard; Insects: The Earth's Most Successful Animals; Wildlife Drawing; and many more.

Fall 1979 Workshops for Young People, designed for children in grades 4 through 7, include The World of Dinosaurs; Exploring with the Microscope; Understanding Animal Behavior; and Leaping Lizards: A Look at Reptiles and Amphibians.

Special Events and Programs

Metropolitan Singers/The Greek Choral Society October 21, 2:00 P.M. Auditorium. Dino Anagnost, conductor and director.

The Raphael Trio October 31, 7:30 P.M. Auditorium. Works by Mendelssohn and Beethoven.

Identification Day November 4, 1:00 to 4:30 P.M. Roosevelt Rotunda. Museum scientists will be on hand to identify miscellaneous natural history objects—bones, skulls, fossils, shells, rocks, stuffed birds, arrowheads, and assorted oddities. Last year's Identification Day brought out such things as Himalayan fossils, slag, and two tuna fish eyeballs in a can of cat food.

Gallery Talks Thursdays at 2:00 P.M. Assemble at the First Floor Information Desk. All gallery talks are free and last about one hour.

Slide Lectures Tuesdays at 2:00 P.M. in the People Center. All slide lectures are free and last about one hour.

Saturday Film Program Saturdays at 2:00 P.M. in the Auditorium. The fall film program begins on Saturday, October 20; all films are free and last about one hour.

For information on gallery talks, slide lectures, and films, call the Department of Education: (212) 873-1300, extension 255 or 462.

The People Center

The Center teaches anthropology to all members of the family through film, dance, lectures, and workshops. Open every Saturday and Sunday from 1:00 to 4:30 P.M. and at other, preannounced times.

Weekend Highlights

Dominican Festival. October 6 and 7. 1:00 to 4:30 P.M. Dances, music, and lecture presentations.

Visions of Grace: Chinese Dance. October 13 and 14. 1:30, 2:30, and 3:30 P.M. The Chinese Dance Company of New York.

Woodwind Quintet. October 27 and 28. 1:00, 2:00, 3:00, and 4:00 P.M. Queens Symphony Orchestra.

African Lecture Series

The Legacy of Weeksville. October 10. 7:00 P.M. Lecture and film. Weeksville, in Brooklyn, was one of the earliest black communities in New York and is now the subject of archeological study.

The Power of Black Religious Sounds: Origin of Gospel Music in America. October 17. 7:00 P.M. Lecture and piano demonstration with L.D. Frazier.

Douglas J. Preston

RSPB

The Royal Society for the Protection of Birds presents an original work of art in fine, hand-painted porcelain

THE EUROPEAN GOLDFINCH

Sculpture shown smaller than actual size. The complete sculpture stands approximately 6½ inches (16cm

Inaugurating the Society's first collection of international bird sculptures in porcelain.
Life size–in a natural setting–and in a single, limited edition.
Intricate art of exceptional beauty, at the very attractive price of $90.

For the first time in its history, the Royal Society for the Protection of Birds has undertaken the creation of a collection of international porcelain bird sculptures.

The European Goldfinch, one of the world's most charming birds, inaugurates the collection. Crafted in fine, hand-painted porcelain, it is both an impressive work of art and a model of ornithological accuracy. And it will be issued at the very modest price of $90 — which may itself be paid in three convenient monthly installments of $30 each.

This new and original work of art has been designed to the Society's commission by the internationally renowned wildlife artist Peter Barrett. The Goldfinch is portrayed clinging to the branch of an almond tree that's aburst with blossoms. The vivid scarlet, black and white of the head . . . the bright bars of yellow upon the wings . . . the delicate formation of the tail feathers . . . all are depicted with realism and accuracy, in authentic natural color.

Moreover, *The European Goldfinch* will be sculptured *life size* in this enchanting work of art, which will be created for the Society by Franklin Porcelain in Japan — home of some of the world's most gifted and experienced porcelain craftsmen.

In the tradition of classic works in fine porcelain, *The European Goldfinch* will be made available in a single, limited edition, reserved *exclusively* for those who order from the Society's first collection of international bird sculptures during 1979. When all valid orders from those individuals have been filled, the edition will be permanently closed. A Certificate of Authenticity bearing the signature of the Director of the Royal Society for the Protection of Birds will accompany each sculpture.

The European Goldfinch, by Peter Barrett, will provide a fascinating focal point of beauty for your home. It will be a conversation piece of which you will never tire. A treasured heirloom, to be deservedly passed along to future generations.

To reserve *The European Goldfinch,* you should act promptly. We would ask you to be sure that your Reservation Application is postmarked by October 31, 1979.

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Please accept my reservation for *The European Goldfinch,* to be handcrafted for me in the finest hand-painted porcelain, at the original issue price of $90.* plus $3. for shipping and handling. I need send no money now. I will be billed in three equal monthly installments, with the first payment due in advance of shipment.

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Looking Down at Everest

Mount Everest, the highest point on earth, looks like this from a Landsat satellite orbiting the planet at an altitude of 570 miles. On the border of Tibet and Nepal, Everest's 29,028-foot-high summit reaches up into the outer layers of the earth's atmosphere. At that altitude, temperatures are extremely low, winds are fearsome, and oxygen is thin. There were eight unsuccessful attempts to climb Everest before it was finally conquered in 1953 by New Zealander Edmund Hillary and Tenzing Norgay, a Sherpa guide from Nepal.

This image of Everest, made in December 1972, is one of fifty Landsat pictures in "Images of Earth from Space," an exhibit assembled by the Smithsonian Institution Traveling Exhibition Service, which will be on view at the Hayden Planetarium-American Museum of Natural History through December 16.

Three Landsat satellites have been launched since 1972; two are still in orbit. With a life expectancy of two years, each satellite circles the globe once every eighteen days, surveying the earth's environment and resources. Satellite images are particularly useful in determining such things as wheat yield, drought areas, and water and atmospheric pollution. They also help in the study of fault lines, rock formations, and in mineral and oil exploration. All the data recorded by the satellites are in the public domain and are widely used by government, industry, and universities.

Landsat pictures are multispectral scanner images. They are based on measurements of the solar radiation reflected from the earth's surface, which are subsequently translated into composite prints by computers. The measurements are made in four different color bands: two in the visible spectrum, two in the infrared part of the spectrum. Every terrestrial feature—vegetation, water, desert soil, rock, and urban area—has a characteristic color. Although their primary purpose is informational, Landsat images also have a visual fascination and, for some, an aesthetic value.

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Additional Reading

Pakhtun Marriage (p. 11)

An Account of the Kingdom of Caubul, by Mountstuart Elphinstone (New York: Oxford University Press, 1973), first published in 1815, is a very entertaining, two-volume record of the Pakhtun, or Pashtoon, people, their territory, and the author's journey in 1809 to Peshawar, the winter capital of the Afghan Kingdom. In *The Pathans 550 B.C.-A.D. 1957* (New York: St. Martin's Press, 1965), Olaf Caroe, who was governor of the North-West Frontier Province in the 1940s, links the Pakhtun with their pre-Islamic ancestry; the book includes photographs and maps. A study of the Pathans, or Pakhtun, of Swat valley, based on data collected in 1954, *Political Leadership among Swat Pathans*, by Fredrik Barth (Atlantic Highlands: Humanities Press, 1970), describes the formal framework of the Swat society. Akbar S. Ahmed's *Millennium and Charisma among Pathans: A Critical Essay in Social Anthropology* (Boston: Routledge and Kegan Paul, 1976), an analysis of the Swat Pakhtun society, with suggestions of alternative models of social organization, has a theoretical slant and is critical of Barth's study. "Social Structure and Sex Antagonism," by Robert Murphy (*Southwestern Journal of Anthropology*, vol. 15, no. 1, 1959, pp. 89-98), discusses men's cults, the separation of the sexes, and cultural symbols.

Underwater Volcano (p. 38)

A well-illustrated account of the modern-day formation of a volcanic island is Sigurdur Thorarinsson's *Surtsey: The New Island in the North Atlantic* (New York: Viking Press, 1967). *Volcanoes of the Earth*, revised edition, by Fred Bullard (Austin: University of Texas Press, 1976), is a comprehensive presentation of volcanology for the layman. Tui De Roy Moore's "Rivers of Lava: Volcanic

Life in the Galápagos'' (*Oceans*, July-August 1979) provides a discussion of the creation of islands in the Galápagos archipelago from volcanoes. *Natural History* recently published two articles of interest: ''The Big Blast at Santorini,'' by Stephen Sparks and Haraldur Sigurdsson (April 1978), and ''Pompeii AD 79: Fiery Vesuvius,'' by Martin Prinz (April 1979).

Swamp Deer (p. 46)

In *The Deer and the Tiger: A Study of Wildlife in India* (Chicago: University of Chicago Press, 1967), a scientific predator/prey study that the lay reader can enjoy, George B. Schaller names eleven localities in Uttar Pradesh where swamp deer were known to live. By 1972 Colin Holloway found that swamp deer remained in only three of these localities. In ''Swamp Deer in Uttar Pradesh'' (*Oryx*, May 1973, pp. 41–48), Holloway estimates the numbers and status of the swamp deer, describes the environmental factors that threaten them, and recommends a conservation program. In 1977 Dietrich Schaaf and Arjan Singh reported on the continuing attrition in ''Barasingha in the Dudhwa Sanctuary'' (*Oryx*, February 1977, pp. 495–98). *Tiger Haven*, by Arjan Singh (New York: Harper and Row Publishers, 1973), includes photographs of swamp deer and discusses the pressures affecting the survival of many of the wild animals living in this part of India.

Yellow Jackets (p. 56)

The Wasps, a paperback by Howard E. Evans and Mary J. Eberhard (Ann Arbor: University of Michigan Press, 1970), is an introduction to wasp biology that gives a very detailed treatment of social wasps. Evans also wrote ''Social Parasitism of a Common Yellowjacket'' (*Insect World Digest*, vol. 2, no. 1, 1975, pp. 6–13), a popular article on one permanently parasitic species. A well-illustrated review of wasp biology with particular emphasis on yellow jackets is J. Philip Spradbery's *Wasps: An Account of the Biology and Natural History of Social and Solitary Wasps* (Seattle: University of Washington Press, 1973). ''*Vespula squamosa*, A Yellow Jacket Wasp Evolving toward Parasitism,'' by J. F. MacDonald and R. W. Matthews (*Science*, vol. 190, 1975, pp. 1003–04), is a short technical report on early discoveries of wasp parasitism.

Huichol Indians (p. 68)

Art of the Huichol Indians, edited by Kathleen Berrin (New York: The Fine Arts Museums of San Francisco/Harry N. Abrams, 1978), is the catalog for the exhibition that is coming to the Museum in November. Available in major bookstores and some museum shops, it contains eight essays by nine contributors. *Peyote Hunt: The Sacred Journey of the Huichol Indians*, by Barbara G. Myerhoff (Ithaca: Cornell University Press, 1976), a thorough analysis written for the lay reader, is available in paperback. Fernando Benitez's *In the Magic Land of the Peyote* (New York: Warner Books, 1976) provides a firsthand account of this historian-journalist's experiences on a ritual peyote journey through the desert. *Symbolism of the Huichol Indians* (Memoirs of the American Museum of Natural History, vol. 3, pt. 1, 1900), by Carl Lumholtz, remains the classic work in the field. First printed in 1902 and now available as a reprint, Lumholtz's *Unknown Mexico: Indians of Mexico*, volume 2 (New York: AMS Press), describes this ethnographer's wanderings through Mexico. *The Huichols: Primitive Artists*, by Robert M. Zingg (Millwood: Kraus Reprint Co., 1976), originally published in 1938, is another important work in the field and can be found in most university libraries.

Bush Babies (p. 76)

G. A. Doyle and R. D. Martin edited *The Study of Prosimian Behavior* (New York: Academic Press, 1979), a collection of papers on subjects including classification, physiology, behavior, learning and intelligence, communication, diet, and ecology. Another relevant collection is *Readings in Sociobiology*, edited by T. H. Clutton-Brock and P. H. Harvey (San Francisco: W. H. Freeman and Co., 1978). A detailed analysis of the behavior and ecology of the five lorisid species in Gabon, *Ecology and Behaviour of Nocturnal Primates: Prosimians of Equatorial West Africa*, by Pierre Charles-Dominique (New York: Columbia University Press, 1977), reveals a great deal about nocturnal mammals in general.

Saddleback (p. 82)

''Cultural Transmission of Song Patterns and Dialect Development in a Free-Living Bird Population,'' by P. F. Jenkins (*Animal Behaviour*, vol. 25, 1977, pp. 50–78), studies songs of individually identifiable saddlebacks living on Cuvier Island from 1970 to 1974. *Bird Vocalizations: Their Relations to Current Problems in Biology and Psychology*, edited by R. A. Hinde (Cambridge: Cambridge University Press, 1969), is a collection of essays reviewing important developments in birdsong analysis in the 1960s. P. Marler and M. Tamura discuss how young sparrows learn their song dialects from older male sparrows in ''Culturally Transmitted Patterns of Vocal Behavior in Sparrows'' (*Science*, vol. 146, no. 11, pp. 1483–86). *To Save a Bird in Peril*, by David R. Zimmerman (New York: Coward, McCann, and Geoghegan, 1975), contains a discussion of the New Zealand Wildlife Service's sanctuary program on Cuvier Island.

Katharine D'Agosta

Jupiter's Walnut in the New World

Lumbermen are stalking our native American black walnut tree

Faced with starvation in the harsh winter of 1609–10, the desperate colonists at Jamestown fed themselves with roots and herbs and other wild foods. They ate what the land gave them, including, it is recorded, walnuts. But these walnuts were not the easily cracked nuts the colonists remembered from pleasant evenings in England. The English, or more properly the Persian, walnut (*Juglans regia*) is a civilized, mild-tasting, easily extracted fruit; the native American black walnut (*Juglans nigra*) is an untamed recluse lurking inside a tough husk, clinging to its shell like a limpet to a rock.

Modern fanciers of this powerful-tasting nut attack the husks with hammers. Some folks even run them under car wheels. The black walnut is definitely a delicacy, with its dark, earthy flavor. Specialty stores and mail-order houses sell it, but the black walnut is too troublesome to rival its old-world cousin, *Juglans regia*, or its American relative the pecan (*Carya illinoensis*) as a commercially cultivated nut tree.

All of these trees, as well as hickories and butternuts, are in the walnut family (Juglandaceae), and they all produce true nuts—hard-shelled fruits with sizable food sources. The family name comes from the Latin word for walnut, *Juglans*, a syncopated form of the original phrase, *Jovis glans*, the acorn of Jupiter. The Romans seem to have borrowed the word from a Greek word of identical meaning, *diosbalanos*, that referred to the European chestnut (*Castanea sativa*).

All the nuts in the walnut family have obvious similarities, but the black walnut is special and it is in danger. There was a time when hardy native trees, some still producing bushels of nuts after useful lives of as long as 250 years, ornamented the landscape with comforting frequency across their huge natural range, from Ontario to Florida and west to the Great Plains. They formed part of the staple diet of various Indian tribes, who knew the nuts would last through the winter.

Indians ate the nuts raw. They also pounded them into "butter," which they sometimes flavored with herbs or used in baking. Recipes survive for cranberry walnut cakes and for maple-black walnut cookies made with cattail flour. One Indian cooking method for black walnut butter, described in Barrie Kavasch's *Native Harvests*, would still be a clever way of separating the nutmeats from the shells. You simply smash the nuts and boil them in water until the meats and oils rise to the surface and can be skimmed off for pounding. Shell pieces settle to the bottom of the pot.

Native Americans were experts at utilizing the Juglandaceae trees around them. They enlivened pumpkin soup with black walnuts and took the sap from *Juglans nigra* for syrup as readily as they tapped maples. The Creeks even prepared hickory milk for their

The American black walnut tree, always a prize hardwood, was used by the colonists of Williamsburg to panel and balustrade their courtroom, right. The fruit has limited commercial value because of its tough husk.

Norman Tomalin Bruce Coleman

corn dishes. The Indians also taught what they knew to the white settlers, who liked black walnuts as much as any Iroquois. But the colonists unfortunately looked beyond the sap and nuts to the trees themselves and quickly discovered that black walnut wood was a wonderful material, hard and lovely. It made fine furniture and resilient gun stocks.

Today, most of the great old trees, over 100 feet high, have been cut for timber. The champion black walnut reported to the American Forestry Association is in the redwood country of Humboldt County, California. It is 132 feet high, has a circumference of 22 feet, and an average crown spread of 133 feet. Most big walnuts that remain are now so valuable that lumbermen stalk them in rural areas, offering top dollar to cut them down and turn them into luxurious planks. This is the end of a process that began in the seventeenth century. Word had reached Europe well before the naturalist-explorer John Tradescant (1608–1662) gathered black walnuts in Virginia for Charles I. Trees were established in England some time after 1650, but the black walnut never became widespread abroad.

In North America, on the other hand, the black walnut was until recently an important feature of rural life. Jasper Woodroof, author of *Tree Nuts*, writes of "annual pilgrimages to the woods before Thanksgiving with baskets, buckets and bags." The black walnut crop provided work, in harvesting and cracking, all through Appalachia.

Wild trees were meanwhile cultivated and hybridized for easier harvesting. The Stabler variety is an example of a strain whose nuts are fairly easy to crack. Descendants of the original tree sprang up twenty miles north of Washington, D.C., and produce nuts that come out of the shell in unbroken halves; some even emerge whole. Other improved varieties, such as Thomas, Ohio, and Myers, start bearing nuts in the second or third year after planting, seven or eight years earlier than native trees. The new varieties, which also have thinner shells, are propagated by grafting scions onto native seedlings.

David Overcash/Bruce Coleman

Anyone willing to plant a black walnut is obviously a saint of horticulture. In a climate of overall decline in production (despite the development of commercial cracking methods), what could be more useful, even patriotic, than to devote some land to this vanishing yet estimable national treasure?

People with a good stretch of well-drained, rich, loose soil of limestone origin at least four feet deep should consider planting a few black walnuts. Because of their extensive root system, trees should be set a minimum of sixty feet apart. And don't plant them near vegetable gardens. Because of an allelopathic interaction with certain plants in the neighborhood of their roots—probably having to do with a toxin, called juglone, produced by black walnut roots—black walnuts will kill alfalfa, tomatoes, potatoes, blackberries, blueberries, and rhododendrons. On the other hand, the growth of beets, snap beans, sweet corn, black raspberries, grapes, and alas, poison ivy is either unaffected or actually improved by contact with black walnut roots.

Taking into account these peculiarities, the best plan is to insure successful pollination by planting more than one variety. Different varieties have overlapping pollination receptivity periods and can pollinate each other in years of very early or very late spring, when there is a risk that, on a single isolated tree, the pistillate female flowers will not be ready when the

pollen is shed from the staminate, trailing catkins. In normal years, however, an individual tree is quite capable of self-fertilization. Black walnuts are monoecious: each tree grows both male and female parts. The male catkins are carried on the previous year's wood, while the female flowers appear on the current spring's new wood.

By July, the little flowers have burgeoned into tough, green spheres. These nuts ripen by late September or early October. After the leaves have fallen, the nuts drop to the ground and can be gathered. But this is only the beginning for the black walnut forager.

Those freshly fallen green nuts, big as limes, surrounded by pulpy husks, are not at all ready to eat. Soon, however, the tight exterior begins to soften, blotches spread, color fades, and then the mess starts. You have to get the husks off. They are magnificently indehiscent. Nature does not lend a hand. A government publication suggests: "The rear wheel of an automobile can be an effective hull remover. Fit one of the rear wheels with a tire chain and jack up the rear with just enough room beneath the tire for the nuts to pass. The chain will remove the hulls as the nuts are forced through the trough formed by the turning wheel." Another expert, R.L. Scheffel, advises crushing them with your heels on flagstones.

Whichever method you use, be sure to wear work gloves and dispensable clothes, for black walnut husks are rich in black dye. Pioneers used it to tint homespun textiles. Because it is indelible, you have to deal with it as best you can. Some of the husk pulp will persist in clinging to the nut. Pick off what you can. Then wash the nuts to remove the remaining black matter. Harry Lesher of Middleburg, Pennsylvania, who processes black walnuts at home, by hand, and does a small business with them, hoses down his nuts.

Still they are not ready. If you cracked a black walnut just after it had come out of its husk, it would be mushy and bitter. Lesher takes the inch-high nuts, with their thinly furrowed, rough, sharp shells, and dries them in shallow racks at the top of his garage. After six weeks to two months, the time finally comes to crack the nuts. Lesher uses a rubber mallet. Other people use metal hammers.

It often takes several blows of the hammer to make a crack. The edible kernel is then exposed and will normally come away from the convoluted shell in several pieces.

At this point, black walnuts can be treated like other walnuts. They are rarely eaten salted, as a snack, but they can be substituted in any recipe that calls for ordinary walnuts. Perhaps the most popular traditional American black walnut dish is black walnut ice cream, a delicacy for the gods, made with our native, feisty acorn of Jove. Proceed as you would for vanilla ice cream, add one cup chopped nuts per quart of ice cream, freeze, and be glad we have not yet turned all our black walnuts into shotguns and chests.

Eighty-one-year-old Myrtle Corn of Salem, Indiana, pounds her walnuts with a heavy stick and scrapes them with a knife to remove the husks. She uses the nuts in her tollhouse cookies.

Mike Fisher

Mrs. Viola Bricker's
Black Walnut Cake

(adapted from a recipe in *The Pennsylvania Dutch Cookbook*)

- ½ cup (4 ounces, or 1 stick) salt butter, at room temperature
- 1½ cups sugar
- 1 teaspoon baking powder
- 2 cups flour
- ¾ cup cold water
- 5 ounces black walnuts
- 4 egg whites
- 1 recipe icing (see below)

1. Grease two 8-inch cake pans.
2. Preheat oven to 350 degrees.
3. Cream butter. Gradually beat in sugar and continue beating until smooth.
4. Sift together the baking powder and flour. Mix into the sugar-butter mixture.
5. Chop all but ½ ounce of the walnuts. You should end up with 1 cup of chopped nuts to add to the cake batter. Reserve the unchopped nuts.
6. Beat egg whites until stiff but not dry. Fold into the batter.
7. Pour equal amounts of the batter into the prepared layer pans.
8. Bake for 30 to 35 minutes.
9. Cool on rack.
10. Unmold the cake layers. Set one on a serving plate. Ice top sparingly. Set the other layer on top of it. Ice top and sides of cake. Decorate with reserved walnuts.

Yield: one 2-layer, 8-inch cake, about 8 servings

Icing

- 8 ounces cream cheese, softened
- 4 tablespoons salt butter, melted
- 2 tablespoons vanilla extract
- 1 pound confectioner's sugar

1. With an electric mixer, beat the cream cheese until it is light and fluffy.
2. Gradually add the melted butter, beating until it is completely absorbed. Add the vanilla and the sugar, beating well after each addition so that the icing is smooth.

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

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November 1979

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Robert G. Goelet, President
Thomas D. Nicholson, Director

Cover: *A cast pectoral of gold and copper is one of the objects in "Gold of El Dorado: The Heritage of Colombia," an exhibition that will open its national tour on November 13 at the Museum. The Quimbaya piece is from the Museo del Oro, Bogotá. Photograph by Lee Boltin. A special section starts on page 36.*

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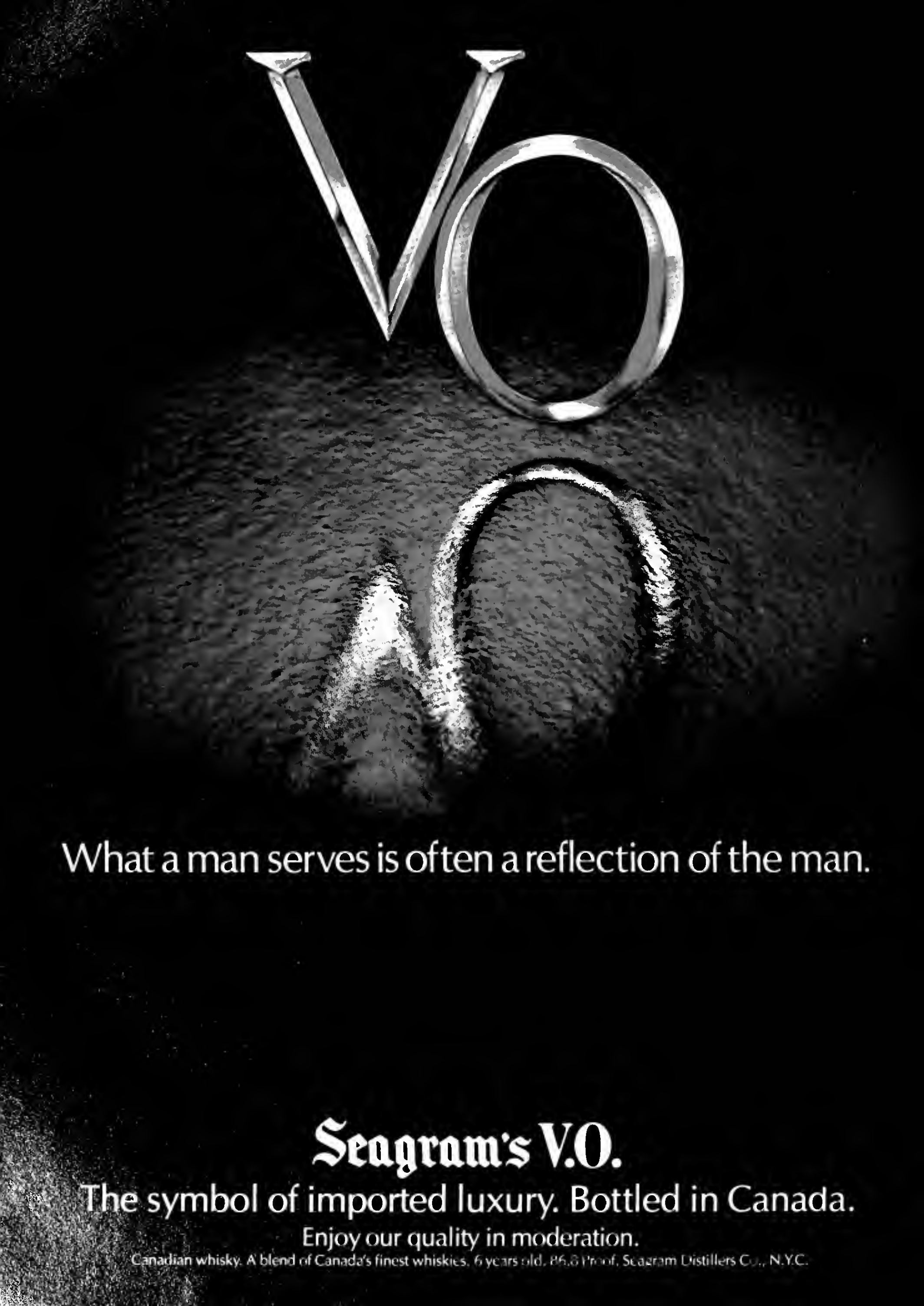
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Clemencia Plazas and coauthor **Ana María Falchetti de Sáenz** are colleagues at the Museo del Oro in Bogotá and are working together on an archeological research project in the San Jorge River Valley in northern Colombia. Plazas joined the museum in 1966 and is now its deputy director; Falchetti de Sáenz is assistant curator and staff archeologist. The museum was organized by the Banco de la República, which, since its foundation in 1923, has controlled the national and international Colombian gold trade. Indian goldwork was first acquired at random, with a few choice pieces housed in the bank's board room. But in 1939, the bank decided to purchase goldwork with a view to forming a collection. The first room at the bank set aside for public viewing was opened in 1946. Now the museum has its own building designed to house and display the collection, which today includes some 26,000 gold artifacts, as well as hundreds of ceramic objects.

Junius Bird, who first did archeological fieldwork for the American Museum of Natural History in 1928, is now curator emeritus in the Museum's Department of Anthropology. His research has taken him on expeditions throughout the New World, from the Arctic Circle to Navarino Island, south of Tierra del Fuego. The study of pre-Columbian metalwork led him to consider the distribution of the stingless bee as a possible explanation for certain regional cultural differences. The textiles of preceramic-era Peru and questions concerning the Paleo-Indian occupation of Panama and southern South America are among his current preoccupations. Recent honors he has received include a decoration from the Peruvian government—Gran Oficial de la Orden "El Sol de Peru"—and the prestigious Explorers Club Medal.

Although he had collected butterflies for more than twenty years, **Matthew M. Douglas** did not become interested in their thermoregulatory strategies until his Ph.D. advisor at the University of Kansas suggested several provocative hypotheses during a lecture on the ecology of tropical butterflies. Now an assistant professor of entomology and ecology at Boston University, Douglas is at present studying the evolution of insect wings, as well as thermoregulation in closely related species of butterflies in arctic, alpine, and temperate habitats. Although he has braved ticks, chiggers, and quicksand in his fieldwork, he maintains that he still enjoys butterfly collecting as "a hobby, sport, intellectual pursuit, and a way of living."

John Miller Chernoff's love of music led him to West Africa where he spent five years learning to play the drums of the Dagomba people. This sojourn is described in his recent book *African Rhythm and African Sensibility* (University of Chicago Press)—a book he hopes "will introduce Western readers to many of the fascinating aspects of music making in Africa and help them appreciate traditional African values." A research fellow at Trinity College, Legon, Ghana, Chernoff's future projects include a book edited from tape-recorded lectures given by a Dagomba drummer and a biographical study of young people on the margins of African urban life. How does Chernoff spend his spare time? Drumming.

Gene S. Helfman began working on coconut crabs while a Peace Corps volunteer on Palau, Western Caroline Islands. His initial project was to determine the breeding periods and maturational sizes of the crabs. This led him to study population regulation in this species, which, in turn, served as the subject of his master's thesis at the University of Hawaii. Helfman received his Ph.D. from Cornell University and is now an adjunct research associate at the University of Georgia. He lives with his wife, Judy Meyer (a faculty member in the university's zoology department), "four mutts, and a cat by a lake in rural Wolfskin, Georgia."

Fred Roll

When Margaret Mead died a year ago, she was especially mourned by the villagers of Pere (Manus Island, Papua New Guinea), to whom she had been both friend and ethnographer for half a century. To share in the community's expression of grief, **Barbara Honeyman Roll** visited Pere last December. A friend and associate of Mead's, Roll first traveled to Pere in 1966, when she was asked to be a consultant in physical anthropology. Although her primary focus was on the study of body types, she rapidly became involved in genealogical and demographic surveys and developed a personal commitment to the people of Pere. Roll lives in Carmel, California, and is currently writing a book on body types with her longtime collaborator Lindsay Carter.

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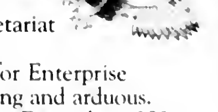

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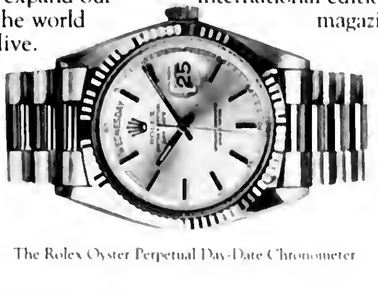

The Rolex Oyster Perpetual Day-Date Chronometer

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The Blue Revolution

With an efficient drip irrigation system, farmers get more crop per drop

by Sylvan H. Wittwer

Agriculture is the world's most basic industry; its success depends in large part on an adequate supply of water. Wherever natural sources such as rainfall and dew are insufficient, irrigation is used. Eighty-five percent of the fresh water now withdrawn from the world's surface and ground reserves is used in agriculture. No other natural resource is so predominantly consumed by one industry. Water may therefore become our most limiting and expensive resource for food production. Unfortunately, water for irrigation is used at present in the United States with only 35 to 40 percent efficiency as compared with 85 to 90 percent efficiency in Israel, for example.

Of the 3.8 billion acres currently under cultivation worldwide, approximately 570 million acres are irrigated. That 15 percent of the land, however, produces 30 percent of our global food supply. Irrigated land is about twice as productive as nonirrigated. Its extent has recently expanded rapidly in the United States and throughout the world in response to the ever increasing demand for more food. Many governments count on the expansion of irrigated acreage as a means not only of increasing food production but also of insuring its stability. It is against this background that an irrigation method known as trickle, or more commonly drip, has been recognized as a promising technology for managing water and increasing its agricultural efficiency. The rapidity with which this system is spreading has prompted the expression "blue revolution" to describe the phenomenon.

Drip irrigation is not new. Its use as a porous hose was reported in Michigan as long ago as 1934, and shortly after World War II the process was employed in the United Kingdom for watering greenhouse-grown vegetable crops, particularly tomatoes. During the early 1950s several experimental installations were established in greenhouses in the United States. What *is*

In drip irrigation, a surface or underground network of pipes provides an automatically controlled flow of water. Shown are California strawberry plants, watered by a system that lies under the plastic mulch.

All photographs by Sylven H. Wittwer

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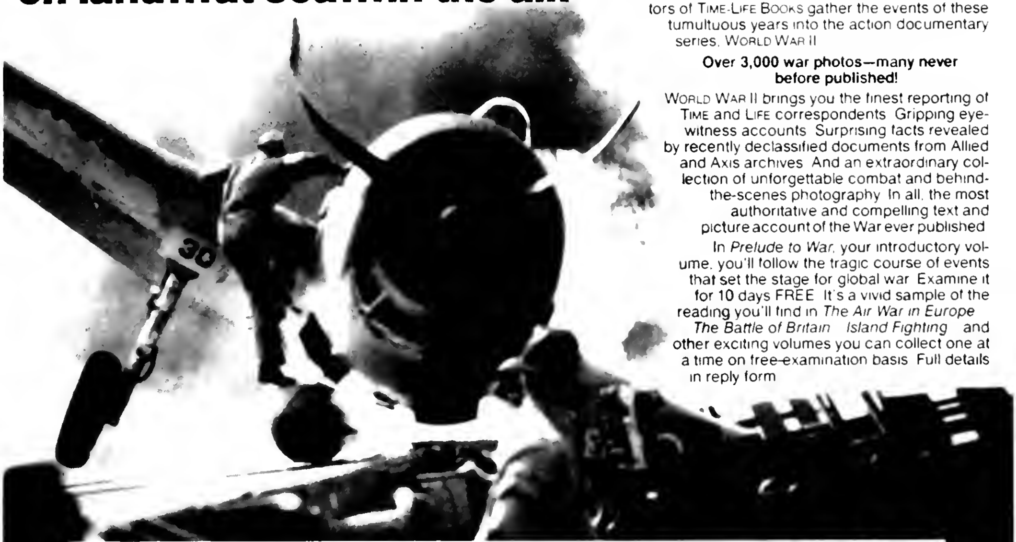

Hermann Göring, a slim flier in World War I.

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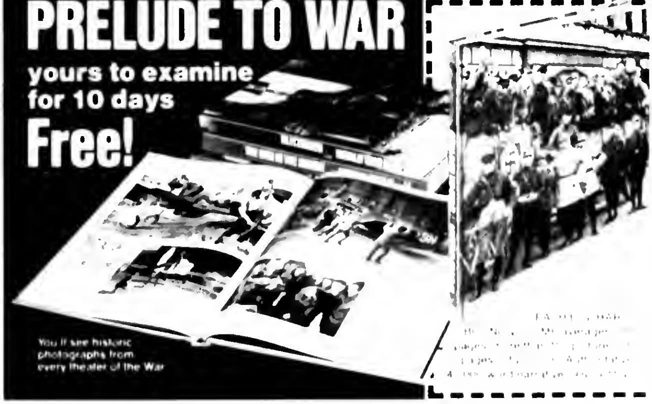

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Here, a highly trained team of scientists and engineers probe fundamental questions about materials and processes. They provide Western Electric factories with pre-tested, proven ways to manufacture products based on the latest technology coming out of the laboratory.

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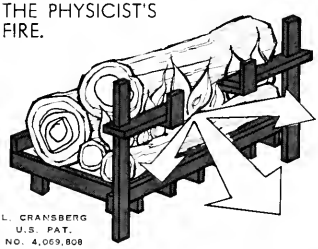

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"A new principle," NY TIMES, 12/29/77, C4.
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The first application of drip irrigation for commercial crop production came some thirty years ago, with greenhouse tomatoes in Western Europe. These tomatoes, in England, grow in peat modules.

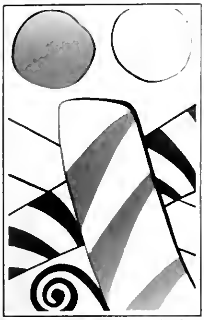
new is the adaptation of drip irrigation to field-grown crops.

In drip irrigation, water is applied slowly and uniformly to a crop at soil level or below, adjacent to the plant. This is done by means of mechanical water outlets called emitters, which are located at selected points along water-delivery lines. Most emitters are placed on the surface of the ground, but they can be buried under the soil for protection and to reduce surface evaporation. Water enters the soil from the emitters and most of the water movement that wets the soil between the emitters occurs by capillary action beneath the soil's surface. The volume of soil moistened by drip irrigation is usually much less than that watered by other methods. With newly planted crops, the soil moistened may be less than 10 percent and with orchard crops less than 5 percent. The principle is to irrigate the crop, not the soil.

A typical drip irrigation system consists of a network of plastic pipes of graduated sizes, which carry the water to the emitters, which in turn control the flow and allow the water to emerge as drops. The rate of flow from a single emitter is usually fixed at one-half to two gallons per hour. Other essential components of a successful drip irrigation system are a meter, filters and screens, injectors for fertilizers and other materials, pressure regulators, and clocks geared to provide a timed application of the water.

The application of drip irrigation to field crops originated in the arid regions of the world. It was first introduced in Israel, using plastic tubing, during the early 1960s. The first experiments, made with subsurface systems, failed because of soil salinization, emitter clogging by roots, mechanical problems, and inexperience. But the subsequent improvement of emitters and the transition to surface systems led to success in the late 1960s.

The initial exposure of the Western world to field installations of drip irrigation occurred at the International



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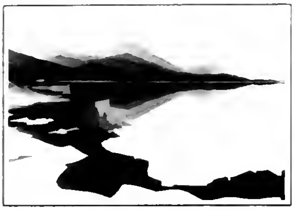

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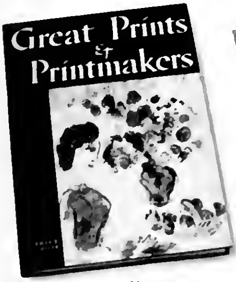

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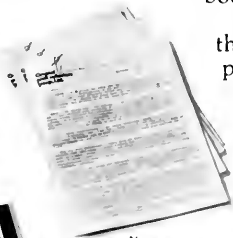

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Horticultural Congress at Tel Aviv, Israel, in March 1970. That year the technology was first introduced in southern California for staked tomatoes and avocados and in Michigan for young cherry orchards.

Worldwide there were approximately 5,000 acres under drip irrigation in 1970, mostly in Israel and Australia. There were less than 200 acres in the United States. By 1974 these figures had grown to 72,000 acres in the United States (half of which were in California) and 140,000 globally. In 1978, figures neared 350,000 acres for the United States and about 550,000 worldwide. The projected figures for 1980 are 500,000 acres in the United States and more than a million worldwide.

Most of the installations in the United States are now found in California, Hawaii, Texas, Florida, Arizona, and Michigan. Some modifications of the system, however, probably exist in every state in the nation in commercial field production, home gardens, or greenhouses. Abroad, large areas in Israel, Australia, South Africa, and Mexico use drip irrigation. Smaller amounts of acreage using drip irrigation are found in Canada, Cyprus, France, Iran, New Zealand, the United Kingdom, West Africa, Italy, Kuwait, Turkey, and the USSR.

Drip irrigation is applicable to many crops, cropping systems, and circumstances. It is now being used on almost all major and minor fruits and vegetables, and for such important crops as potatoes, corn, cotton, sorghum, alfalfa, wheat, coffee, bananas, and sugar cane. All flowers, ornamental trees and shrubs, forest trees, cactuses and other succulents, and bulbs respond to drip systems, and they are now widely used for all kinds of nursery crops as well.

Systems for outdoor production were first developed for high-value crops such as tomatoes, cucumbers, melons, strawberries, and tree fruits in desert or drought areas. Systems were then quickly adapted for sugar cane plantations in Hawaii, which now constitute the single most important field application of the blue revolution. Approximately 50,000 acres of drip systems are now installed in Hawaii with an increase of 10,000 additional acres each year. The ultimate goal is full conversion of all irrigated sugar cane (approximately 100,000 acres) in Hawaii. Drip lines expected to last for eight years are now being installed at depths of twelve to eighteen inches so that the surface soil is not moistened.

Drip irrigation systems for commercial crop production found their first application thirty years ago with greenhouse tomatoes in Western Europe. Many improvements have occurred since then, and drip systems are now widely used in controlled-environment agriculture both for greenhouse cucumbers and tomatoes and for bedding and potted plants. This method of irrigating is admirably suited for home vegetable and flower gardens. It is widely used for ornamentals and shrubs and for maintaining windbreaks. With this system, water can be effectively supplied to orchards, vineyards, plantations, ground covers for highways, street medians, road cuts, and turf. Drip watering systems for indoor vegetable gardens have also been designed.

Drip irrigation has many attractions and advantages. Labor costs may be greatly reduced. For Hawaiian sugar cane plantations, for example, this means that the entire installation cost

Sugar cane is the single most important field application of the "blue revolution." This crop in Hawaii is watered by surface lines. Hawaiian cultivators are rapidly converting all 100,000 acres of irrigated cane to this method.

On Photographing a Small Step

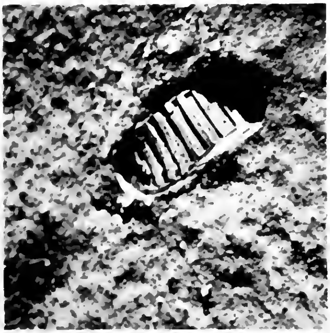
It is unearthly. The landscape underfoot. It is soft and powdery.

A silver beast stands there. His head is a shiny globe. His huge frankfurter fingers hold a small box that talks.

Click. Whir. Click. Whir.

A man is taking the first pictures on the moon. He takes them with a camera that gives him startling detail. It is a Hasselblad.

It is the first of twelve taken to the moon on six landings. And it is still there today.



Photograph by Hasselblad courtesy of NASA

Hasselblads have taken tens of thousands of photographs during millions of miles of travel in space.

In all, 60 Hasselblads on 27 flights with 67 astronauts have completed 3566 orbits of earth and 363 of the moon.

Every Hasselblad proved reliable on every flight under every condition.

Today, 10 years after, Hasselblad celebrates mankind's giant leap with a commemorative issue of a limited edition (earth version) of the 500EL/M motor drive camera that took those historic photographs.

The only medium format camera on earth or in space that can equal it, is another Hasselblad.

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And the possibilities are infinite.

There is a dial set in the body that will order the camera to fire in any of five different ways.

From single shot to speeded up continuous firing at the rate of one shot every 8/10th of a second.

That means you can walk away from the camera, devoting all your concentration to your subject, while firing with a remote cable.

Plug in the intervalometer, for instance, and you can trigger the camera automatically. At any moment you want, from 2 seconds to 14 minutes.

Or trigger up to four cameras simultaneously with a command unit.

Or, fitted for remote radio control, fire from a half mile away.

And the standard film frame on a Hasselblad is 2¼ inches square, *almost 4 times the area* of a 35mm frame. So the ability to hold sharpness and contrast is phenomenal. (For actual size of film frame, see box at lower right.)

The eyes of a Hasselblad

A Hasselblad can see with any one of 22 lenses; all multi-coated (except for two special purpose lenses) in focal lengths from 30mm to 500mm with angular fields from 180 degrees to 9 degrees.

There are lenses for sports, aerial, architectural, and fashion photography. Portrait, landscape, medical, underwater and news photography. Wildlife, laboratory, industrial and child photography.

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There is even the 105mm Zeiss UV-Sonnar f4.3 which can photograph the ultraviolet portion of the electromagnetic spectrum with costly quartz elements that can detect radiations unseeable by the human eye.

There are also lenses that adjust the aperture fully automatically as the light changes.

Even if you are not yet into these more exotic applications but simply recording travel and everyday happenings, it's nice to know that your camera produces the very best images in the medium format.

So, in effect, there is nothing you can't see with a Hasselblad. And photograph. From what is invisible to the naked eye to all that is visible in the universe.

Is it any wonder then that NASA came to Hasselblad for the camera which was to photograph space? And that top professional and serious amateur photographers still rely on Hasselblad.

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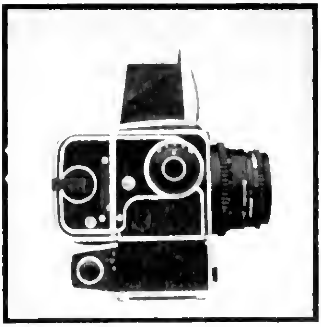

The Motor Drive Hasselblad 500 EL/M, made in Sweden. The standard lens is a multi-coated Zeiss Planar 80mm f/2.8 T*

and capital investment of approximately $600 per acre is returned within the first year of operation. One reason is that although they must be regulated, drip irrigation systems do not need to be tended. Regulation is usually accomplished by automatic timing devices. Providing the precise amount of water required for plant growth eliminates the wide fluctuations in soil moisture that result when water is supplied periodically by other irrigation methods. Reductions in fluctuations between wet and dry extremes provide for better soil aeration.

Drip irrigation guarantees maximum use of the available water. Plants utilize as much water from drip irrigation systems as from other systems, but loss of water by evaporation is minimized. This results in greater efficiency in the use of the applied water. Also, because much of the soil surface is not moistened, weed growth is reduced. This, in turn, lowers labor and chemical costs for weed control and makes uninterrupted orchard operations possible. For row crops, spaces between the rows can remain dry and provide solid footing. Soil and crop management and harvest operations can accordingly be conducted at the same time the crop is being irrigated.

In addition, drip irrigation can use water of higher salinity than would be acceptable with other irrigation methods. In the drip method, accumulated salts are pushed to the periphery of the wetted soil by the advancing front of water. Thus the roots are able to take up water that is essentially of the same level of salt as in the irrigation water. In consequence, yields are usually increased and crops grow more uniformly. This facilitates mechanical harvesting. Furthermore, fertilizers can be injected into the drip irrigation water. This greatly reduces the labor needed for ground applications and, with fruit trees, may reduce the fertilizer requirement by as much as 50 percent.

Overall, costs for irrigation may be greatly reduced not only in labor for operations but also in power and equipment. The pressure required for a typical drip irrigation system is only five to fifteen pounds per square inch whereas that for a sprinkler irrigation system is from forty to one hundred pounds per square inch. Less power is needed for pumping, and the lower pressures reduce the cost of piping.

Finally, drip irrigation systems can be adapted to uneven and marginal land, such as hillsides, that cannot now be cropped or irrigated by conventional furrow or flood systems, thereby bringing that acreage into production. No land is wasted in building irrigation ditches, there is no need to flatten land for gravity flow, crops can be cultivated without undue soil erosion, and many crops can be grown in succession and in undisturbed beds. Drip irrigation also reduces the environmental problems of leaching that often result in drainage water pollution.

Despite its many advantages, drip irrigation does have its drawbacks. The most serious is the plugging of the water outlets, or emitters. This upsets the distribution system and may result in plant damage from either too much or too little water. Water used for drip irrigation systems, especially that taken from ponds or lakes, must be free of solid particles. The low velocity flow and the small openings in the delivery lines and emitters require that the water be carefully filtered at the head. Elaborate filtration systems for large field operations have been designed. Similarly, attention must be given to filtering water used for small plots.

Other problems involve ants, which may clog the tubes in a search for water, and rodents, which may chew the tubing. Sandy soils of good infiltration are best adapted to drip irrigation. If the infiltration rate is less than one-half inch per hour the soil may puddle and the free water around the plant will run or accumulate. Medium-textured soils produce well with drip irrigation; fine-textured or clay soils are a problem. Salt accumulations in saline areas around the periphery of the wetted areas and from excess drying between waterings can also become a difficulty.

On balance, however, the advantages of drip irrigation far outweigh its disadvantages, and its future looks bright. As the demand for, and the cost of, food production and water grows greater, this remarkable technology for increased efficiency in water use will expand. Almost all food-producing areas of the world have deficiencies of water at one time or another during the growing season. The meteoric rise of the blue revolution, which we have witnessed during the past decade, is therefore expected to continue.

Sylvan H. Wittwer is professor of horticulture and director of the Agricultural Experiment Station at Michigan State University.

Reader's Digest COMMAND PERFORMANCE

Partial Listing of Selections and Artists

Record One: ***Curtain Up***
The Barber of Seville Overture, Metropolitan Opera Orchestra, Erich Leinsdorf, Conductor; *Die Fledermaus* Overture, Vienna State Opera Orchestra, Oscar Danon, Conductor; *Don Giovanni* Overture, Chicago Symphony Orchestra, Fritz Reiner, Conductor.

Record Two: ***World Famous Arias***
Largo al factotum—*The Barber of Seville*, Robert Merrill; Mi chiamano Mimì—*La Bohème*, Anna Moffo; Che gelida manina—*La Bohème*, Richard Tucker; Un bel di—*Madama Butterfly*, Leontyne Price; Celeste Aïda—*Aïda*, Placido Domingo; Habanera—*Carmen*, Leontyne Price; La donna è mobile—*Rigoletto*, Alfredo Kraus; Bell Song—*Lakmê*, Anna Moffo; Evening Star—*Tannhäuser*, Sherrill Milnes; Vissi d'arte—*Tosca*, Leontyne Price; E lucevan le stelle—*Tosca*, Jussi Bjoerling; Musetta's Waltz—*La Bohème*; Mary Costa, Anna Moffo, Robert Merrill.

Record Three: ***Best-Loved Duets***
Love Duet, Act I—*Madama Butterfly*, Leontyne Price & Richard Tucker; Barcarolle—*The Tales of Hoffmann*, Montserrat Caballé & Shirley Verrett; Love Duet, Act I—*Tosca*, Zinka Milanov & Jussi Bjoerling; Final Scene—*Carmen*, Leontyne Price & Franco Corelli.

Record Four: ***Rousing Choruses***
Anvil Chorus—*Il Trovatore*, Robert Shaw Chorale & Orchestra; Soldiers' Chorus—*Faust*, Robert Shaw Chorale & Orchestra; Pilgrims' Chorus—*Tannhäuser*, Norman Luboff Choir, New Symphony Orchestra of London, Leopold Stokowski, Conductor; Bridal Chorus—*Lohengrin*, Robert Shaw Chorale & Orchestra.

Record Five: ***Gala Performance***
Toreador Song—*Carmen*, Robert Merrill; O patria mia—*Aïda*, Leontyne Price; Drinking Song—*La Traviata*, Montserrat Caballé & Carlo Bergonzi; Quartet—*Rigoletto*, Anna Moffo, Rosalind Elias, Alfredo Kraus & Robert Merrill; The Flower Song—*Carmen*, Franco Corelli; Casta diva—*Norma*, Montserrat Caballé.

Record Six: ***Dances from the Opera***
Dance of the Comedians—*The Bartered Bride*, National Symphony Orchestra, Howard Mitchell, Conductor; Dance of the Apprentices and Entrance of the Mastersingers—*Die Meistersinger*, Chicago Symphony Orchestra, Fritz Reiner, Conductor; Gypsy Dance—*Carmen*, Leontyne Price, Vienna Philharmonic Orchestra, Herbert von Karajan, Conductor; Bacchanale—*Samson et Dalila*, Boston Pops Orchestra, Arthur Fiedler, Conductor.

Record Seven: ***Pageantry and Splendor***
Triumphal March—*Aïda*, Boston Pops Orchestra, Arthur Fiedler, Conductor; Magic Fire Music—*Die Walküre*, Boston Symphony Orchestra, Charles Munch, Conductor; Ride of the Valkyries—*Die Walküre*, Symphony of the Air Orchestra & Women's Chorus, Leopold Stokowski, Conductor; Prelude to Act III—*Carmen*, Vienna Philharmonic Orchestra, Herbert von Karajan, Conductor.

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Perceptive Bees, Birds, and Bacteria

Many creatures orient themselves within their environments in ways we can hardly imagine

The famous words "blessed art thou among women" were uttered by the angel Gabriel as he announced to Mary that she would conceive by the Holy Spirit. In medieval and Renaissance painting, Gabriel bears the wings of a bird, often elaborately spread and adorned. While visiting Florence last year, I became fascinated by the "comparative anatomy" of Gabriel's wings as depicted by the great painters of Italy. The faces of Mary and Gabriel are so beautiful, their gestures often so expressive. Yet the wings, as painted by Fra Angelico or by Martini, seem stiff and lifeless, despite the beauty of their intricate feathering.

But then I saw Leonardo's version. Gabriel's wings are so supple and graceful that I scarcely cared to study his face or note the impact he had upon Mary. And then I recognized the source of the difference. Leonardo, who studied birds and understood the aerodynamics of wings, had painted a working machine on Gabriel's back. His wings are both beautiful and efficient. They have the right orientation and camber, the correct arrangement of feathers. Had he been just a bit lighter, Gabriel might have flown without divine guidance. In contrast, the other Gabriels bear flimsy and awkward ornaments that could never work. I was reminded that aesthetic and functional beauty often go hand in hand (or rather arm in arm, since I write of wings).

In the standard examples of nature's beauty—the cheetah running, the gazelle escaping, the eagle soaring, the tuna coursing, and even the snake slithering or the inchworm inching—what we perceive as graceful form also represents an excellent solution to a problem in physics. When we wish to illustrate the concept of adaptation in evolutionary biology, we often try to show that organisms unconsciously "know" physics—that they have evolved remarkably efficient machines for eating and moving. When Mary asked Gabriel how she could possibly conceive, "seeing I know not a man," the angel replied: "For with God nothing shall be impossible." Many things are impossible for nature. But what nature can do, she often does surpassingly well.

Good design is usually reflected by correspondence between an organism's form and an engineer's blueprint. In *Science* for March 30, 1979, I encountered an even more striking example of good design: an organism that builds an exquisite machine within its own body. The machine is a magnet; the organism, a "lowly" bacterium.

When Gabriel departed, Mary went to visit Elizabeth, who had also conceived with a bit of help from on high. Elizabeth's babe (the future John the Baptist) "leaped in her womb" and Mary pronounced the *Magnificat*, including the line (later set so incomparably by Bach) *et exaltavit humilis*, "and [he hath] exalted them of low degree." The tiny bacteria, simplest in structure among organisms, inhabitants of the first rung on traditional (and fallacious) ladders of life, illustrate in a few microns all the wonder and

D L Balkwill

A magnetotactic bacterium (top) with its chain of tiny magnets (X 40,000)

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beauty that some organisms require meters to express.

In 1975, University of New Hampshire microbiologist Richard P. Blakemore discovered "magnetotactic" bacteria in sediments near Woods Hole, Massachusetts. (Just as geotactic organisms orient toward gravitational fields and phototactic creatures toward light, magnetotactic bacteria align themselves and swim in preferred directions within magnetic fields.) Blakemore then spent a year at the University of Illinois with microbiologist Ralph Wolfe and managed to isolate and culture a pure strain of magnetotactic bacteria. Blakemore and Wolfe then turned to an expert on the physics of magnetism, Richard B. Frankel of the National Magnet Laboratory at M.I.T. (I thank Dr. Frankel for his patient and lucid explanation of their work.)

Frankel and his colleagues found that each bacterium builds within its body a magnet made of twenty or so opaque, roughly cubic particles, measuring about 500 angstroms on a side (an angstrom is one ten-millionth of a millimeter). These particles are made primarily of the magnetic material Fe_3O_4 (ferric oxide), known as magnetite, or lodestone. Frankel then calculated the total magnetic moment per bacterium and found that each contained enough magnetite to orient itself in the earth's magnetic field against the disturbing influence of Brownian motion. (Particles small enough to be unaffected by the gravitational fields that stabilize us or the surface forces that affect objects of intermediate size are buffeted in a random manner by the thermal energy of the medium in which they lie suspended. The "play" of dust particles in sunlight provides a standard illustration of Brownian motion.)

The magnetotactic bacteria have built a remarkable machine, using virtually the only form that could work as a compass within their tiny bodies. Frankel explains why the magnetite must be arranged as particles and why the particles must be about 500 angstroms on a side. To work as an efficient compass, magnetite must be present as so-called single domain particles, that is, as bits with a single magnetic moment, containing opposite north- and south-seeking ends. The bacteria contain a chain of such particles, oriented with their magnetic moments north pole to the next south pole along the row—"like the elephants head to tail in a circus finale," as Frankel states. In this way, the entire chain of particles operates as a single magnetic dipole with north- and south-seeking ends.

If the particles were a bit smaller (less than 400 angstroms on a side), they would be "superparamagnetic"—a big word indicating that thermal energy at room temperature would cause internal reorientation of the particle's magnetic moment. On the other hand, if the particles were greater than 1,000 angstroms on a side, separate magnetic domains pointing in different directions would form *within* the particle. This "competition" would reduce or cancel the particle's overall magnetic moment. Thus, Frankel concludes, "the bacteria have solved an interesting problem in physics by producing particles of magnetite of just the right size for a compass, of dimension 500 angstroms."

But evolutionary biology is preeminently the science of "why," and we must ask what such a small creature could possibly do with a magnet. Since a bacterium's cruising range is probably a few inches for the few minutes of its existence, I have difficulty believing that oriented motion in a north or south direction can play any role in its repertoire of adaptive traits. But what preferred direction of motion might make a difference? Frankel suggests, quite plausibly in my view, that an ability to move *down* might be crucial for such a bacterium—for down is the direction of sediments in aquatic environments, and down might lead to a region of preferred oxygen pressure. In this instance, "them of low degree" might wish to debase themselves even further.

But how does a bacterium know which way is down? With the smug prejudices of our enormous selves, we might think the question inane for its obvious answer: all they have to do is stop whatever they are doing and fall. Not at all. We fall because gravity affects us. Gravity—the standard example of a "weak force" in physics—affects us only because we are large. We live in a world of competing forces, and the relative strength of these forces depends primarily upon the size of objects affected by them. For familiar creatures of macroscopic dimensions, the ratio of surface area to volume is crucial. This ratio decreases continually as an organism grows since areas increase as length squared and volumes as length cubed. Small creatures, insects for example, live in a

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world dominated by forces acting on their surfaces. Some can walk on water or hang upside down from a ceiling because surface tension is so strong and the gravitational force that might pull them down so weak. Gravitation works on volumes (or, to be more precise, masses that are proportional to volumes in a constant gravitational field). Gravitation rules us with our low ratio of surface to volume. But it affects an insect very little—and a bacterium not at all.

The world of a bacterium is so unlike our own that we must abandon all our certainties about the way things are and start from scratch. Next time you see *Fantastic Voyage* on the tube, take your eyes off Raquel Welch and the predacious white blood corpuscle long enough to ponder how the miniaturized adventurers would really fare as microscopic objects within a human body (they behave just like regular folks in the film). They would, first of all, be subject to shocks of the Brownian motion, thus making the film something of a random blur. Also, as Isaac Asimov pointed out to me, their ship could not run on its propeller, since blood is too viscous at such a scale. It should have, he said, a flagellum—like a protozoan.

D'Arcy Thompson, premier student of scaling since Galileo, urged us to set aside our prejudices if we would understand the world of a bacterium. In his masterpiece, *Growth and Form* (published in 1942 but still in print), he ends his chapter "On Magnitude" in his incomparable prose:

> Life has a range of magnitude narrow indeed compared to that with which physical science deals; but it is wide enough to include three such discrepant conditions as those in which a man, an insect and a bacillus have their being and play their several roles. Man is ruled by gravitation, and rests on mother earth. A water-beetle finds the surface of a pool a matter of life and death, a perilous entanglement or an indispensable support. In a third world, where the bacillus lives, gravitation is forgotten, and the viscosity of the liquid, the resistance defined by Stokes's law, the molecular shocks of the Brownian movement, doubtless also the electric charges of the ionized medium, make up the physical environment and have their potent and immediate influence upon the organism. The predominant factors are no longer those of our scale; we have come to the edge of a world of which we have no experience, and where all our preconceptions must be recast.

So how does a bacterium know

which way is down? We use magnets for horizontal orientation so exclusively that we often forget (in fact, I suspect many of us do not know) that the earth's magnetic field also has a vertical component, its strength depending upon latitude. (We damp out the vertical deflection in building compasses because it doesn't interest us. As large creatures ruled by gravitation, we know which way is down. Only at our scale could folly be personified as not knowing "which way is up.") A compass needle follows the earth's lines of force. At the equator, these lines are horizontal to the surface. Toward the poles, they dip more and more strongly *into* the earth. At the magnetic pole itself, the needle points straight down. At our latitude, the vertical component is actually stronger than the horizontal. A bacterium, swimming north as a free compass needle, also swims down at Woods Hole.

This proposed function for a bacterial compass is pure speculation at the moment. But if these bacteria use their magnets primarily to swim down (rather than to find each other, or to do Lord knows what, if anything, in their unfamiliar world), then we can make some testable predictions. Members of the same species, living in natural populations adapted to life at the equator, will probably not make magnets, for here a compass needle has no vertical component. In the Southern Hemisphere, magnetotactic bacteria should have reversed polarity and swim in the direction of their south-seeking pole.

Magnetite has also been reported as a component of several larger organisms, all of which perform remarkable feats of horizontal orientation —the conventional use of a compass for familiar creatures of our scale. Chitons, eight-plated relatives of clams and snails, live primarily on rocks near sea level in tropical regions. They scrape food from the rocks with a long file called a radula—and the tips of the radular teeth are made of magnetite. Many chitons make substantial excursions from a living site, but "home" back to the precise spot thereafter. The idea that they might use their magnetite as an orienting compass suggests itself, but the evidence so far offers no support. It is not even clear that chitons have enough magnetite to perceive the earth's field, and Frankel tells me that their particles are mostly above the single domain limit.

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affected by the earth's magnetic field (see article by J.L. Gould, no relation, J.L. Kirschvink, and K.S. Defeyes in *Science*, September 15, 1978). Bees do their famous dance on the vertical surface of their honeycomb by converting the orientation of their flight to food in relation to the sun into an angle danced with respect to gravity. But if the comb is turned so that bees must dance on a horizontal surface, where they cannot express direction in gravitational terms, they become disoriented at first, but after several weeks, align their dances to the magnetic compass. Moreover, a swarm of bees, placed into an empty hive without cues for orientation, build their comb in the magnetic direction it occupied in their parental hive. Pigeons, certainly no duffers at homing, have a structure made of magnetite located between the brain and skull. In an article in *Science* (September 7, 1979), C. Walcott, along with J.L. Gould and J.L. Kirschvink, reports that this magnetite exists as single domains and can therefore function as a magnet.

The world is full of signals that we don't perceive. Tiny creatures live in a different world of unfamiliar forces. Many animals of our scale greatly exceed our ranges in sensations familiar to us. Bats avoid obstacles by bouncing sound off them at frequencies that I cannot hear, although some people can. Many insects see into the ultraviolet and follow the "invisible" nectar guides of flowers to sources of food for them and pollen to be carried to the next flower for fertilization (the plants build these orienting color streaks for their own advantages, not to convenience the insects).

What an imperceptive lot we are. Surrounded by so much, so fascinating and so real, that we do not see (hear, smell, touch, taste) in nature, yet so gullible and so seduced by claims for novel power that we mistake the tricks of mediocre magicians for glimpses of a psychic world beyond our ken. The paranormal may be a fantasy; it is certainly a haven for charlatans. But "parahuman" powers of perception lie all about us in birds, bees, and bacteria. And we can use the instruments of science to sense and understand what we cannot directly perceive.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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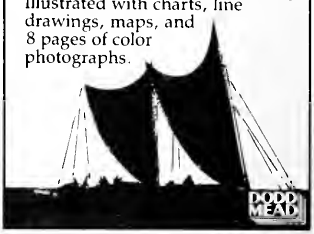

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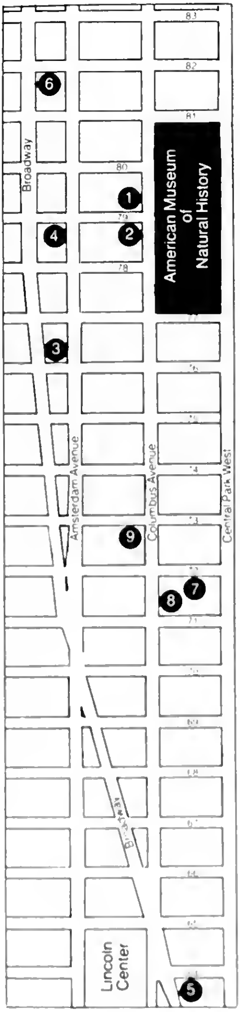

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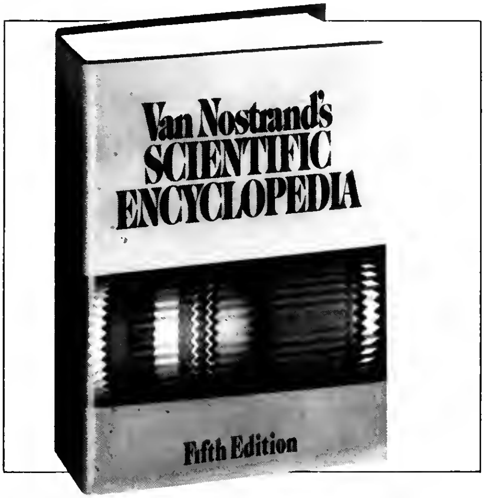

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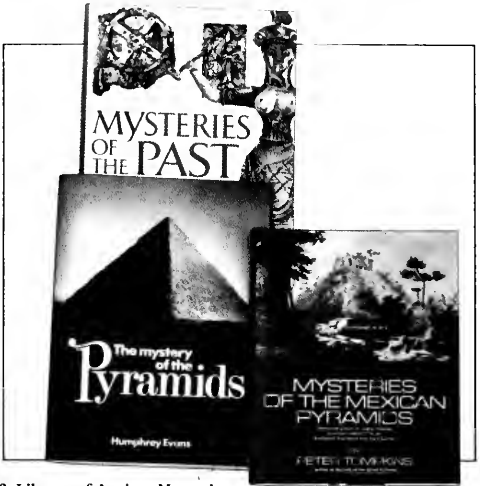

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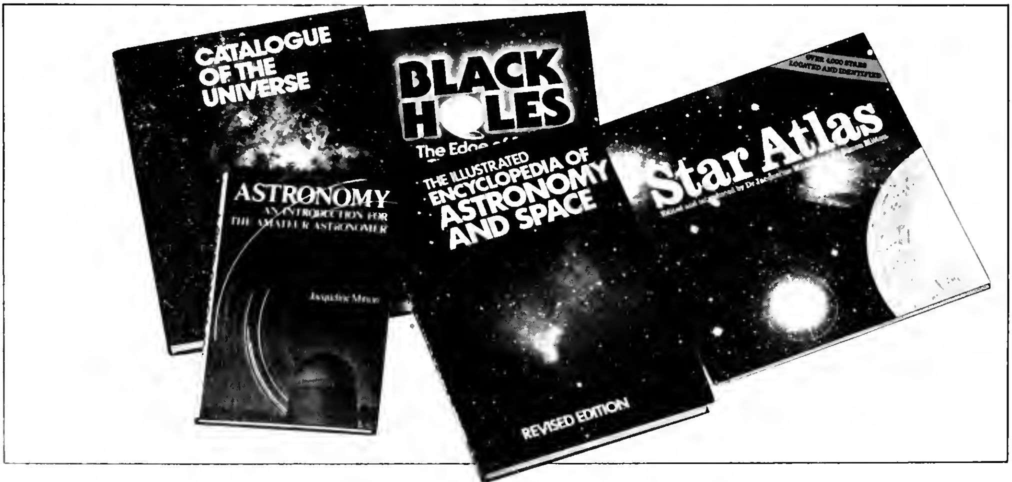

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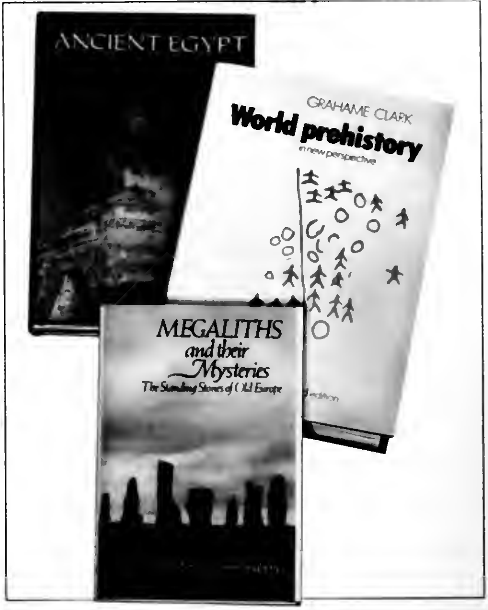

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GOLD of EL DORADO

More than 500 pieces of goldwork and over 100 objects of pottery, stone, and cloth—a generous sample of Colombia's brilliant pre-Hispanic heritage—are featured in a special exhibition at the American Museum of Natural History, November 13, 1979, to March 18, 1980. Most of these artifacts were selected from the collection of the Museo del Oro in Bogotá, which for the first time has made them available for display in North America. The exhibition illustrates the styles and techniques characteristic of Colombia's various goldworking areas, as well as the use of cast and hammered gold to make votive figurines, funerary masks, ear and nose ornaments, animal pendants, elegant flasks, and utilitarian objects.

[illegible]nal tour of "Gold of El Dorado: The Heritage of Colombia" is sponsored by Chemical Bank, with additional support from the National Endowment for the Humanities and the National Endowment for the Arts.

Technology of Ancient Colombian Gold

by Clemencia Plazas and Ana María Falchetti de Sáenz

photographs by Lee Boltin

Pre-Hispanic Indians living in the territory that is now Colombia employed almost all the goldworking techniques known to the New World. A detailed knowledge of this elaborate technology comes from the analysis of existing artifacts, especially the 26,000 objects preserved in the Museo del Oro of Bogotá, Colombia. These pieces are remarkably varied, reflecting the different cultural origins and traditions in the region, as well as the geographical and climatic diversity.

The earliest archeological evidence for Colombian metalwork dates back to the final centuries B.C. and is for the southwest of the country—the Calima and Tumaco areas, and an early stage of Tierradentro and San Agustín metallurgy. Perhaps the greatest continuity of development in a single area occurred in the middle Cauca River valley. Starting about the time of Christ and continuing until the Spanish conquest in the early sixteenth century, this area was a center of experimentation with, and diffusion of, techniques. The last stage of Colombian metallurgy is represented mainly by the goldwork of the Tairona, Sinú, Muisca, and Nariño areas, which were prominent after the fifth century A.D.

Goldworking flourished among those Indian societies that had achieved a certain level of cultural complexity. They were sedentary communities with an economy based mainly on intensive agriculture, the staple being maize. There was social stratification, centralization of power, and specialization of labor; goldsmiths enjoyed particularly high status among the specialist groups.

In some regions, there were towns inhabited exclusively by goldworking artisans, who made products for their own group as well as for trade with neighboring tribes. In the Sinú area, for example, thousands of objects were produced—mainly false-filigree earrings—using a manufacturing technology that included many well-defined steps. The various steps could be fulfilled by different individuals within the group of specialists, and it is possible that the mechanical jobs were carried out by apprentices. There were also itinerant goldsmiths, such as those of the Muisca town of Guatavita, who went from place to place offering their skills.

The need for raw materials promoted the development and organization of mining. Since raw gold was one of the most important items of trade, the mining areas became centers from which trade routes radiated. Buriticá, the most important mining center of pre-Hispanic Colombia, was the junction of numerous commercial routes that covered a large part of Colombian territory and extended into Central America, Venezuela, and Ecuador. Different regions traded such items as surplus foods or manufactured goods to obtain the raw gold.

Mining and goldworking were separate occupations, each involving a series of technical developments and a definite specialization of its own. In many mining centers, Indians concerned themselves entirely with the extraction and trading of raw gold, whereas in other regions goldsmiths obtained their raw material through trade. The manufacture of gold pieces in the mining centers, when present, was a secondary activity, very different from the specialization and large-scale production in the major goldworking areas.

The gold deposits of Colombia are found in the andesite formations of the Cordilleras Occidental and Central and in the numerous, alluvium-rich rivers that drain these mountain ranges. Buriticá, in the mountainous part of Antioquia, was made up of a group of settlements whose inhabitants worked exclusively at mining. Some of the deposits there were privately owned, and the chiefs enjoyed the privilege of employing their subjects in the mines as a form of taxation. There is evidence that in most of the important mining centers, the placer, or alluvial, mines were worked by slaves, who were usually prisoners of war from neighboring tribes.

For the most part, pre-Hispanic peoples obtained gold from placer mining, hoeing the riverbanks and riverbed with sticks that had fire-hardened points. The earth was sluiced to produce a gold-bearing residue, which was then panned in flat wooden trays. Times of drought were preferred for

Sinú jaguar pendant, Museo del Oro

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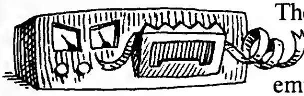

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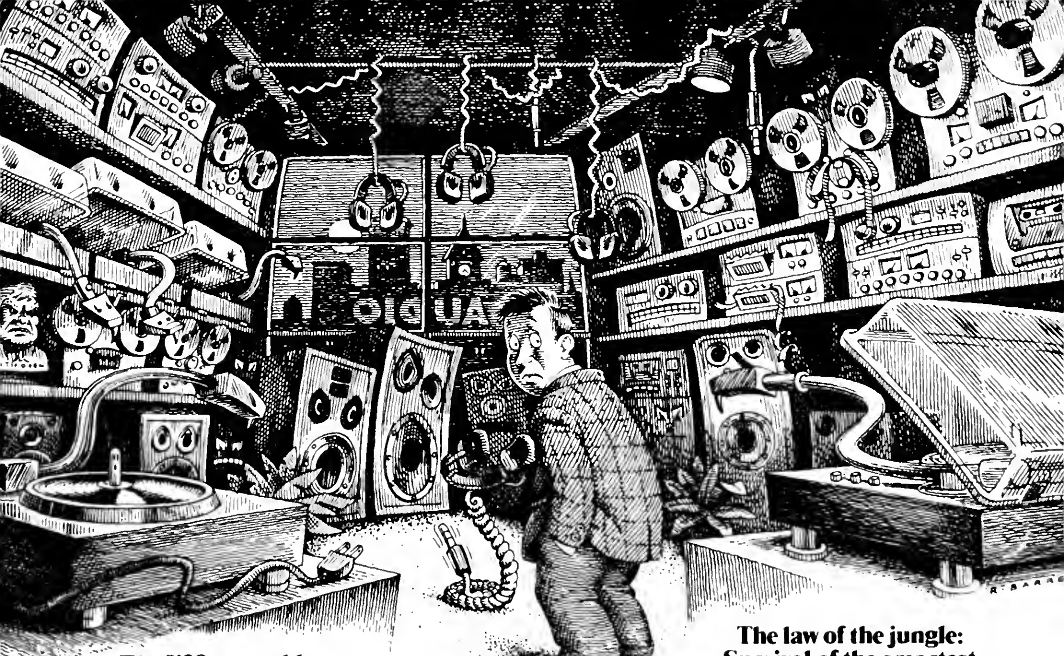

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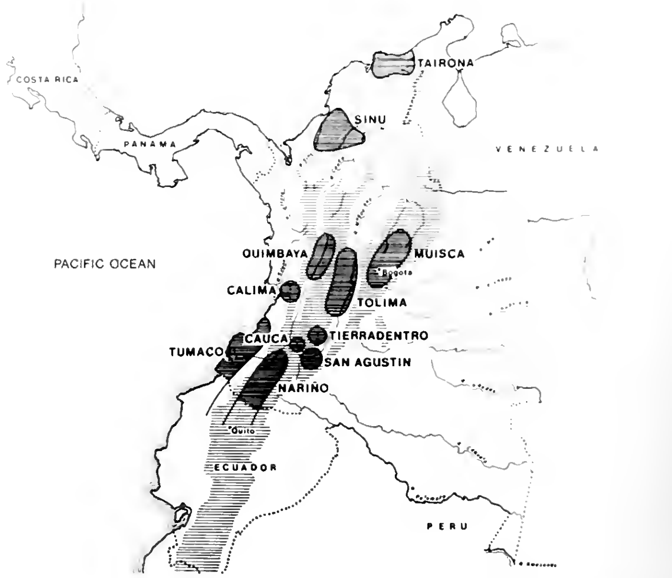
Goldworking Regions of Colombia



Museo del Oro

these activities. In 1513, chronicler Vasco Nuñez de Balboa wrote:

They wait until the rivers rise . . . and after the floods have passed, and they become dry again, the gold is exposed, having been washed from the banks and carried from the mountains in very large nuggets.

In the rainy season, they used nets to procure gold from the rivers and streams, as mentioned in this somewhat fanciful description by Martin Fernández de Enciso, 1518:

And when it rains they stretch nets across the streams and when the water rises it brings nuggets as big as eggs which are caught in the nets.

The Indians also worked gold accumulated in alluvial terraces by diverting and canalizing the waters of streams, causing them to flow over the banks where the gold was washed and separated from gravel.

Vein gold was worked in certain regions. In the northwest of Antioquia are the remains of shafts dug by the Indians to work the quartz veins and extract gold. They used stone tools to dig very narrow shafts, about three feet in diameter, sometimes at an angle of thirty or forty degrees, until the quartz was reached. Some mines reached a depth of sixty to eighty feet, but no chambers or underground galleries seem to have been used. The working of vein gold sometimes involved preparation of the land around the mines. Nuñez de Balboa writes:

Another way they procure gold is by waiting until the vegetation on the hills is dry and then setting fire to it; afterwards they search for gold in the high parts and most likely places, and they obtain great quantities of gold in very handsome nuggets.

The ore was then ground in stone mortars and panned for the gold.

There is evidence that in some mining centers gold obtained from veins or alluvial deposits was put through a smelting process to separate the pure metal for its easy transport. The Indians had the equipment needed to do this close to the mines. In Buriticá, there were portable furnaces and crucibles to smelt gold and "small Roman balances and weights to weigh the gold" (Piedro Cieza de León, 1664). In the Museo del Oro there is a small crucible from Tumaco, made of refractory clay. Such vessels were placed in furnaces, made of fired refractory clay, the upper part made to accommodate charcoal and one or two crucibles. In Colombia only one example is known: a furnace from Manizales, measuring 28 centimeters (11 inches) in diameter.

The temperature required to melt the metal was achieved with the aid of ceramic blowpipes; the interior of the pipe narrowed toward one end to increase the force of the air as it left the tube. As a result of the smelting, a small disk, or button, of variable diameter (1.28 cm average) was left in the bottom of the crucible. One face of the disk (*tejuelo*) is usually smooth, while the other shows rough impressions from the ceramic surface. The variations in gold content, form, and weight of these small ingots suggest that there was no strict control over this phase of gold processing.

Alluvial and vein gold contain varying quantities of additional metals or metalloids—such as osmium, iridium, platinum, bismuth, arsenic, antimony, iron, lead, zinc, and silver—which modify the behavior of the gold during working. A sufficient quantity of these impurities creates what is known as bitter gold, which, unlike sweet gold, is almost impossible to work. The pre-Hispanic Indians probably refined impure gold in the following manner: the gold dust was heated to a dull red with common salt and clay, and the chlorine in the salt then combined with the impurities to form chlorides, which were driven off as gases. In this way the grains were covered with a layer of fine gold, which became thicker as the procedure was continued and the temperature increased. The process, known as cementation, was used in the mint of Santa Fe de Bogotá from 1627 until 1838, supposedly following the Indian tradition. Gold refined in this way could be easily hammered, embossed, or cut.

The nature and quantity of the impurities in gold depend on the geologic formations from which the deposits come. As a result of the uneven control the pre-Columbian goldsmiths had over the refining process, the source of the material used in a given piece can be determined by painstaking comparative metal analyses both of worked pieces and of raw gold.

The goldsmiths who lived in Colombian territory worked mostly in gold and copper, and on a smaller scale, in silver and platinum. The use of high-grade gold, generally for hammered pieces, was characteristic only in two

A mold with an inner core was needed to cast this hollow Quimbaya lime container. Lime, obtained from crushed seashells, was chewed with coca, a drug used in magical and religious practices.

Museo de América, Madrid

Luis Fernando Barriga

For casting an object such as this ear ornament, a model was made by assembling prepared wax threads.

A funnel and channels were also modeled in wax, to allow the molten gold to flow freely during casting.

The model was then dipped repeatedly in liquid clay, to thoroughly cover all the fine structures.

The whole was then encased in firmer clay. When dry, the mold was placed on a fire to melt out the wax.

Molten gold was poured into the funnel opening to fill the space left by the "lost" wax model.

Finally, the mold was broken and cleaned away. In finishing, the funnel and conduits were removed.

of the Colombian goldworking areas—Calima and Tolima. Alloys of gold and copper predominate elsewhere. Some hammered and cast pieces of almost pure copper have also been found.

There are rich copper mines in the Cordillera Oriental and in some regions of the Cordillera Central, where several indigenous groups worked raw copper. In parts of South America, in what is now Bolivia, Argentina, and Chile, the Indians mined copper ores, such as carbonates and sulfides, which were then refined. The Indians of Colombia may also have used copper ores to obtain the metal, but neither archeological evidence nor metal analysis has yet been produced to verify this.

A principal technical characteristic of metalworking in Colombia, Panama, and Central America is the use of tumbaga, a binary alloy of gold and copper that may contain some minor impurities. When gold is mixed with copper in certain proportions (about 70 percent copper to 30 percent gold), the melting point of the metals is reduced some 250°C. Gold fuses at 1,063°C, copper at 1,083°C, and tumbaga at 800°C. Considering the conditions under which the pre-Columbian metalsmiths conducted smelting, this reduction of temperature offered a considerable advantage. In addition, pieces cast in tumbaga reproduce decorative details from the mold more finely than those made in almost pure copper or gold.

The quantity of gold and copper employed, the size of the pieces, and the techniques used in a given region depended on the availability of raw materials in that area. Goldware from the Calima and Tolima regions, naturally rich in gold deposits, is usually large, hammered, and of high-grade gold. By contrast, most pieces from the Muisca and Tairona areas, where gold deposits are scarce, are either cast or gilded tumbaga and are smaller in size and weight.

Indian goldsmiths well appreciated the qualities of ductility, malleability, and durability of gold, as well as its glitter and fine appearance, and often used it to gild the surface of tumbaga pieces. Despite the frequency of gilding, the colors of copper and the various alloys were also appreciated for their own decorative effect. In some cases, tumbaga pieces were covered with a final layer of silver; in Peru, they were even painted.

As far as is known, the working of silver occurred only in the Nariño region of southern Colombia. Pieces from this area show strong influences, both in style and in metallurgical techniques, from regions farther south in present-day Ecuador and Peru. Silver

Cast filigree, distinctive of Sinú work, was modeled with wax threads, as detailed above. These ear ornaments, adorned with stylized birds, were made of gilded tumbaga, a widely used gold-copper alloy.

Museo del Oro

pieces are practically unknown elsewhere in Colombia.

In the collection of the Museo del Oro there are a dozen hammered nose rings from the western part of the country that are worked in alloys containing varying amounts of platinum. As a result of their gold and copper content, these objects could be heated until they were soft without having to be raised to the high temperature (1,780°C) needed to melt platinum. The pieces retain the pale color, greater weight, and hardness of platinum.

Traditionally, hammering has been considered the first developed and most primitive technique for making gold objects. This may be true in a narrow sense—when different stages of the development of metallurgical techniques over the centuries are analyzed—but not all hammered pieces are necessarily older than cast objects. New finds are being made of pieces manufactured by seemingly simple techniques, such as hammering, associated with objects made by techniques classified as complex, such as casting. In some goldworking areas, both techniques were used in manufacturing a single piece.

The use of hammering was related to local traditions and external cultural influences, as well as to the existence of gold deposits in given regions. Its use was most frequent in the south, west, and center of the country, regions very rich in gold deposits and in contact with Peruvian and Ecuadorian groups who were masters of this technique.

Hammering actually requires more manual skill and greater knowledge of the behavior of the metal throughout the working process than casting does. This can be seen in the large *repoussé* breastplates from the Calima area and in the thin, broad gold sheets that were employed as funerary vestments by the Indians of the Sinú. To achieve this size and fineness, the goldsmiths worked gold ingots, placed on cylindrical stone anvils, with small, oval hammers made from meteoric iron.

Cast in gold by the lost-wax method, this Muisca Indian pectoral is 7⅛ inches high. There were social distinctions concerning the quantity and quality of gold ornaments members of a group were permitted to wear.

Museo del Oro

The two flat faces of the hammer enabled them to thin the gold sheets against the flat face of the anvil, while the hammer's convex sides could be used to form curved surfaces.

After a number of blows, a gold sheet becomes brittle and subject to cracking. It must be reheated until it glows red; then cooled by quenching in water. This process, known as annealing, or tempering, allows hammering to continue until the desired size and thickness are achieved. The process, described in a sixteenth-century document in the Archivo General de Indias, Seville, must be carefully regulated, as the Indians understood:

> And in this way, placing it [a bracelet] in the fire, taking it out and putting it in water and hammering it on an anvil with the stones described they worked until they had increased its size many times.

Once a sheet of uniform thickness was obtained through hammering and tempering, a general outline of the intended decoration was traced on its surface, and the metal was then pressed from behind to raise the marked design. This work was carried out with metal, stone, or bone tools—chisels, tracers, burnishers, and punches—with the gold sheet placed on a soft surface, such as thick leather or a bag of fine sand. Afterward, the piece was worked from the front face with a chasing tool to deepen further the depressed areas and emphasize the raised design. Work continued in this way on the alternate faces of the object, but whenever a piece became brittle the goldsmith had to temper it before proceeding, to avoid any break.

In order to make hollow objects of some volume and complexity of form in sheet gold, the Indian goldsmiths developed several joining techniques. The simplest was to unite the separate parts with gold nails or to hammer a bifolded "seam" to join two gold sheets. In this way the goldsmiths sometimes used gold sheet to cover nonmetallic objects. In the Calima area there are gold pieces in the form of seashells, flutes, trumpets, and ceremonial staffs, which at one time probably covered actual shells or wooden cores now decomposed.

In a more complex process, known as fusion welding, small gold balls, wires, or sheets were joined to one another, to make or decorate objects of great delicacy. This method, known to Etruscan and Greek goldsmiths as granulation, was also used in the Americas, especially in the south of Colombia and the northeast of Ecuador. A join of this kind could unite two metal pieces of varying gold content. If the parts to be joined were both of high-grade gold (18 to 24 carats), a drop of copper acetate, obtained by dissolving copper in vinegar, and some drops of organic glue were placed where the parts touched. The component sections were then heated with a slow flame in a reduced atmosphere; the goldsmiths blew on the fire through canes to create the oxygen-free atmosphere ideal for this operation. During this highly sophisticated procedure, the small amounts of glue burned off and the added drops of copper acetate formed an alloy with the gold, causing a molecular interchange and fusion at the points of contact. No addition of copper acetate was necessary when tumbaga sections were being joined.

Fusion welding is an extremely delicate operation and needs high temperatures, controlled to about 25°C lower than the melting point of the metal. The slightest error can destroy a piece, but the join obtained is strong and almost imperceptible to the naked eye.

Another technique known in the New World was lost-wax casting, possibly developed first in Colombia or Central America, judging by the predominance of cast objects in these regions and the variety of modifications of the technique that occur there. Although metal castings are encountered in all the goldworking regions of Colombia, this technique was most prominent in the center and north of the country (the Quimbaya, Sinú, Tairona, and Muisca regions).

Lost-wax casting is a standard technique, which, once learned, can be readily repeated. The goldsmith needs to comprehend the behavior of the metals and alloys on fusion, but the process itself does not involve the manual skill that is indispensable when working directly with gold.

The success of a casting depended on a number of factors: the homogeneity of the alloy used; the design of the wax model, to allow a rapid and total flow of the liquid metal; and the speed with which the operation was carried out, to avoid cooling of the metal before all the spaces were filled. Many of the surviving pieces show formal features that, apart from being decorative, aided the flow of the molten metal during casting—for example, the limbs of the Muisca figurines. The exterior mold was made of a porous

material that permitted air and gases to escape during the casting process. For this reason, in the making of relatively small objects, such as those cast in pre-Hispanic Colombia, it was not necessary to add wax tubes for the gases to escape.

When the cast pieces were containers or hollow objects open at the back, such as the anthropomorphic Tairona pendants, they were made by the lost-wax method with an independent inner core. The core, made of a mixture of clay and charcoal, was modeled in the shape of the desired object and then entirely covered with a layer of beeswax. This layer of wax was pierced by bamboo or wooden pegs, penetrating about one centimeter into the clay core to hold it in place during casting. The whole was then covered by an outer clay mold. When the hot wax was removed, the supports held the core in position and prevented it from obstructing the flow of molten metal.

The size and number of pegs varied, apparently depending on the skill and foresight of the goldsmith: some pieces were cast with three, others with thirty-six. Once a casting was finished, the outer mold was broken and the supports removed. The circular holes left by the pegs were repaired with a thick metal wire placed like a nail in the orifices. The line created by such a repair joint was disguised by subsequent polishing. Finally, if it was called for, the interior core was removed, presumably by scraping.

All hollow containers of this kind come from the Quimbaya area, where the goldsmiths undoubtedly reached the highest level of technical ability in metalworking. One example of this refinement is a Quimbaya pin that was cast in several stages, each casting involving a different alloy in order to vary the chromatic effect. The result is an articulated pin of different colors.

For the manufacture of identical pieces, stone matrices were carved from soft slate to obtain a design in high relief. Most of the stones that have been found are in the form of a parallelogram and have several motifs on each face. If one of the designs became worn, that particular face was recarved. The matrix was used for impressing the required form into soft clay. When the clay was dry, the mold was filled with wax, and the stone matrix pressed into it once more. The result was a wax model printed on both faces, in positive and negative impression. When produced in series, such models could be used for lost-wax casting a number of identical objects.

The wax models were used in the manufacture of necklace beads and votive figurines called *tunjos* and were at times joined to wax sheets to form, in conjunction with other elements, larger pieces such as breastplates and ear pendants. Only the Muisca Indians appear to have used the stone matrix technique.

The surface treatment of gold pieces varied from region to region and often depended on their intended use. Votive offerings—in particular, the Muisca *tunjos*—show no after treatment at all. On the other hand, personal ornaments, containers, and utensils, which were intended to last a long time, were burnished, polished, and often gilded. The cast filigree Sinú ear pieces are an exception; although they were often gilded, they were never polished.

For centuries, the pre-Columbian goldsmiths gilded their work for various purposes, including protection of tumbaga pieces against rapid copper oxidation. The conquistadors mistakenly thought the Indians' sole purpose in changing the surface color was to deceive them by simulating objects of pure gold. They complained that pieces they received as tribute payment, or even as a result of pillaging, had the appearance of pure gold but were in reality made of copper alloys, that is, tumbaga, much less valued by the Spaniards.

Through much experimentation, Indian goldsmiths achieved different gilding techniques, which were altered according to the alloy to be gilded. They were also able to vary the local effects of gilding on the surface of a single piece to achieve a decorative pattern.

In pre-Columbian America the best known of several gilding methods was the *mise-en-couleur* technique. When heated, a gold-copper alloy oxidizes to form a layer of copper oxide, which can be removed by an acid solution. This leaves a surface layer of gold, which can then be made thicker by repeating the process. In Ecuador and Colombia, plants of the Oxalidaceae family were used to make the acid solution, which, if applied immediately after heating a piece, accelerated the oxidation of the copper. In a document in the Archivo General de Indias, the Indians are described as working a tumbaga piece

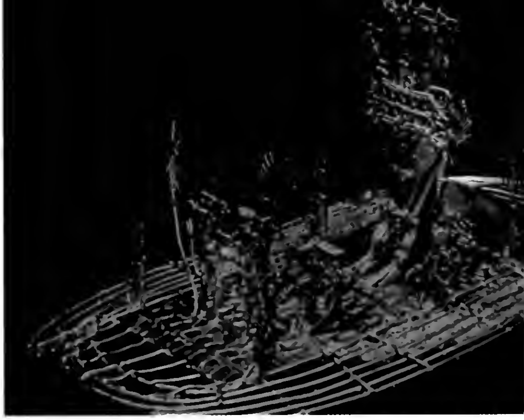
> until it was finished . . . and then the herb they brought to give it color was crushed on a stone and once crushed in this way they placed it in a small pot which they brought in and added water and ground white salt and stirred all together [then they polished, heated and quenched it in the solution several times] . . . and in this way it attained the colour and finish it should have.

If the object to be gilded was made of an alloy containing at least 30 percent gold, this method produced good results. But if the object contained less than 30 percent gold, another gilding method, "superficial parting," was required to obtain a thick layer of surface gold. This process, like *mise-encouleur*, depends on the elimination of base metals, leaving an exposed layer of pure gold. This is achieved, however, by using a corrosive agent of mineral origin, such as iron sulfide, instead of the organic acid made from oxalis plants.

Contrary to common assumption, such gilding methods had little to do with saving amounts of gold, since the processes just described actually left a considerable amount of gold hidden within the alloy.

Some gilded objects were decorated with varying surface textures. Once the piece was gilded, corrosive agents were applied to give it a matte appearance. Afterward the goldsmith burnished restricted surface areas to create a decorative pattern. When a homogeneous and shining surface was desired, objects, including those that had been gilded, were polished by rubbing them with water and an abrasive such as fine sand. Metal, horn, bone, or stone tools were used to burnish hammered or cast pieces; steady pressure was applied to smooth the surface and to create a compact outer layer, which also acted as a protective covering.

The Indians took special care in the finishing of pieces that were used for personal adornment. Gold was treasured by the most eminent individuals of a tribal society, and there were clear social distinctions concerning the quantity and quality of gold ornaments various members of a group were permitted to own. It would be a mistake to think that the "material value" of gold was introduced entirely by the Europeans. But to this must be added a religious value. Gold was given to the gods in the form of votive offerings; it was buried with the dead; and many gold objects served as special symbols in the various rites and ceremonies of the Indian peoples. □



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Did an insect affect goldworking techniques in the New World?

by Junius Bird

The plundering Spaniards and subsequent treasure hunters melted down an immense fortune in pre-Columbian gold artifacts, leaving practically no description of what they destroyed. The objects that survived, however, reveal the skill attained by the New World craftsmen. Sophisticated metallurgical techniques were mastered throughout a large area comprising central and southern Mexico, Central America, Colombia, Ecuador, Peru, northern Chile, western Bolivia, and northwestern Argentina. But archeologists who have studied the historical and regional variations in style and manufacture have noted a curious fact: the scarcity among Peruvian finds of the delicate cast objects characteristic elsewhere, mainly in Colombia, Central America, and Mexico. Perhaps an ecological explanation can be offered for this contrast in cultural development.

In Peru, gold and gold-alloy objects were largely executed by hammering, annealing, chasing, soldering, and related procedures. This technology was the product of a long tradition of goldworking. In fact, the earliest evidence we have of metalworking in the New World with tools made specifically for that purpose is from Peru. Archeologist Joel Grossman, while excavating in the highlands near Andahuaylas, discovered a cache of two rough stone bowls containing three carefully made stone hammers and what appears to be an anvil stone, associated with tiny bits of thin sheet gold. This find has a radiocarbon age of approximately 3,440 years.

By about the same time, people living around Lake Superior in North America were extracting nuggets and large chunks of copper that could be found in the loose gravels or embedded in rock formations and were making them into useful items by cold hammering. This relative abundance of raw copper gave rise to a considerable traffic in the material and cultural adaptation to its use. A great many pit mines were dug in the metal-producing outcrops, using cobblestone hammers and fire to fracture and break up the rock. Some production of such copper persisted until the eighteenth century. In all this long period, however, no one discovered how to melt and cast the metal or how to smelt the ores. Although some items were made so skillfully as to appear cast, metallurgical studies have ruled that out.

In addition to copper, meteoric iron was probably found and used by early peoples, without the benefit of a specialized metalworking technology. The early nomadic hunters of the New World could also have found gold nuggets as they searched along stream channels, beaches, and other places for the stones from which they fashioned their tools and weapons. At first, such nuggets may have been regarded as a

Detail of a Chimu beer goblet: Indians of Peru, who excelled in hammered goldwork, formed the cup from a flat disk. It was then filled with pitch or resin, for support, while the repoussé *design was worked.*

Junius Bird

AMNH, loaned by Frank S. Hermann

This 3¼-inch-high silver figure was cast in an eleven-piece mold. It holds five ears of corn and is adorned with corn leaves, gourds, and fruits. Perhaps lacking wax, the Peruvian artist did not exploit the more suitable wax-model process

Edward Ross

Before the importation of European honeybees, pre-Columbian Indians obtained wax from stingless bees of the family Meliponidae. Here, bees in the foothills of Paraná, Brazil, add wax to the rim of the nest opening.

novel type of stone, of little or no practical value. Or they may have been made into simple ornaments. But in South America, the metallurgical properties of gold were eventually discovered, possibly independent of Old World influence.

Gold occurs in a pure or nearly pure state, soft and malleable and highly resistant to the chemicals found in natural environments. Easily shaped by hammering, it also has a melting point, slightly below copper's, that can be achieved with charcoal, a commonly available fuel. Once the technique was discovered, the melting of the metal in a crucible made possible the utilization of small scraps and particles. Melting, in turn, led to the art of casting.

Casting, as it developed in the New World, was far more than the pouring of molten metal into an open hollow, or form. In Mexico, Central America, and Colombia, intricate and delicate casting was done with wax models. (This process is commonly called lost-wax casting, but this is an uninformative term for the creation, in gold or some other metal, of a replica of a wax original.) If the object was to be hollow, a core was prepared over which the wax was applied. Otherwise, the artist worked only with wax, building up or assembling fine strips or extruded threads of wax and shaping them into delicate patterns, forms, or figures. Wax was also added so that the mold would have a pour hole and, if needed, vents. The model was then encased in ceramic clay mixed with crushed charcoal, to make a mold, which was dried and fired to melt out the wax and prepare it for the metal.

Once the casting was completed, the mold had to be broken to free the finished piece. Great quantities of fragments of such molds must exist where they were discarded by the pre-Columbian goldsmiths, but they have been overlooked or ignored. The pieces of such molds preserved in museums and private collections are so few that all of them could be held in one hand.

In Peru, objects fashioned by the wax-model process were extremely rare and not part of the normal production. Perhaps there was no ready supply of the needed wax, the only source of which was the numerous native species of stingless, honey-producing bees. Members of the family Meliponidae, which is widely distributed in the tropics and some subtropical regions of both the Old and New Worlds, these bees are distinct from the stinger-equipped honeybees imported by the Europeans. Meliponidae bees are found in Mexico at least as far as 22° north latitude, in Central America, and in much of South America as far south as northern Argentina. They are absent, however, from the highlands and west coast valleys of Peru—the regions

of goldworking—as well as from Chile, farther south.

Colombia, in contrast, had an abundance of bees and plenty of the wax. This wax is still sold in the markets, although it is now often mixed with wax from wild colonies of European bees. Dark, almost black, it contains dirt and trash from the nest, as well as dead bees, and is much in need of cleaning and straining.

The use of this wax in Mexico, probably by Mixtec Indians, was recorded in detail by a sixteenth-century historian, Fray Bernardino de Sahagún. His text, as translated from Aztec, states that the goldsmiths "especially esteem beeswax," that "it was mixed with white copal [a resin] so that it would [become firm] and harden well. Then it was purified, it was strained [to remove] its foreign matter, its dirt, the impure beeswax." Among the Maya, the Mixtec, and other Mexican groups, some Meliponidae species were domesticated and kept in various types of hives. Such was not the case among any of the people with whom the Peruvians had contact.

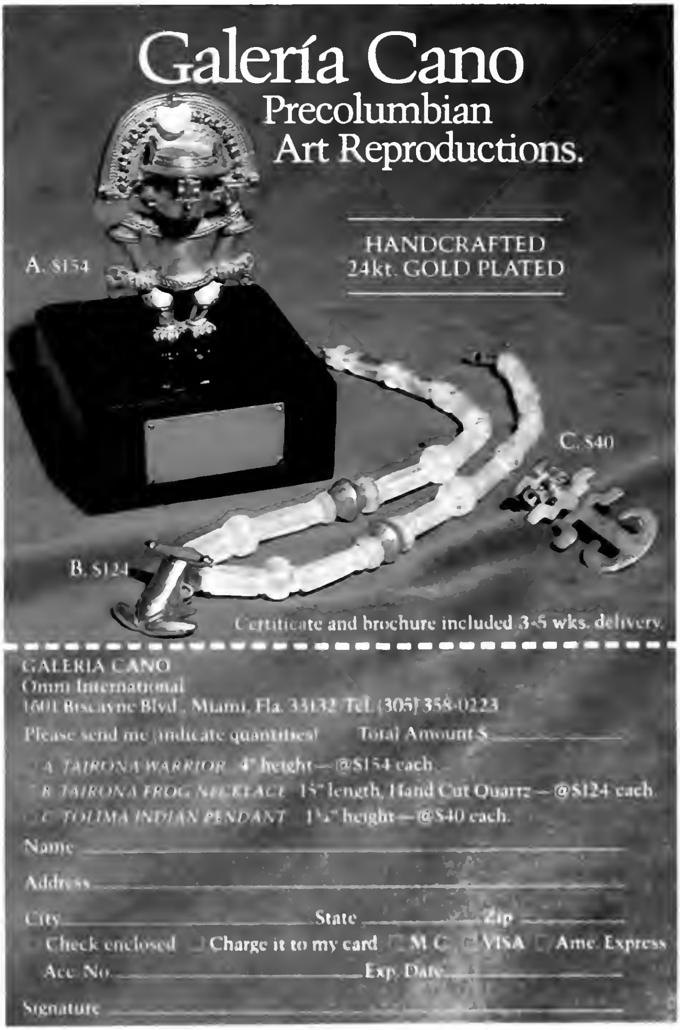
The Peruvians may have obtained beeswax by barter from the north or from the western Amazonian forests. We know that the Incas demanded some beeswax as tribute from a group of Amazonian Indians and that when the Spaniards told these Indians to step up production (so that the churches might have candles), they protested that this was impossible.

In Peru we do find skillful, complex castings in copper—ceremonial staff heads and ornaments, tools, and other items—made in one-piece molds. These objects were first formed in some substance that could be melted or burned out of the molds, but we do not know what it was. The copper products do not have the detail and delicacy that can be achieved with beeswax. Some plant waxes, resins, and gums may have the necessary properties and, if available, could have been an important component of the modeling material used in Peru. Some metal casters in Africa today use the milky sap of a tree, which hardens like chewing gum.

The alternative types of molds were open molds and molds made of two or more pieces. Such molds were used for many centuries by Peruvian potters and were also used for casting copper tools and weapons. The object to be cast could first be formed of any substance—clay, wood, soft stone—since the original model could be removed without the necessity of melting or burning it off. If a sectional mold was being made, it would then be reassembled to receive the molten metal. After casting was complete, the mold was again removed in sections. If undamaged (probably far less often the case for metal casting than for ceramic casting), the mold could even be reused.

The most complex multipiece mold from Peru that I know of was used to cast a small, silver figure of a dancer or ceremonial participant. The mold was in eleven parts, as indicated by the tracings of the junctures that show up in the finished casting and mar its appearance. Had the makers been accustomed to creating their models of beeswax, they would never have attempted this more complicated, time-consuming work.

Although the Peruvians achieved considerable artistry by hammering and related techniques, I believe they were disadvantaged by a scarcity of the beeswax that was available in other goldworking areas. If so, we have here one more instance of the involved interrelationship of insects and humans—this time in the realm of art. □



At the Museum

Gold of El Dorado: The Heritage of Colombia, the stunning new exhibition at the American Museum of Natural History, emerges from the dedicated and skillful work of thousands, beginning with the Indian artisans of prehistoric Colombia and continuing with warriors, traders, priests; grave robbers and archeologists; collectors and bankers; museum curators and deslgners, restorers and preparators, painters and electricians, and many more, including the uniformed guard who each morning, starting November 13 will unlock the glass doors of Gallery 3.

But the current presentation of this golden legacy is greatly influenced by the vision of one person—Ralph Appelbaum, the overall designer of the show.

Standing in front of a scale model, complete with tiny, cutout people, Appelbaum explained that the exhibition space is divided into several areas. The first illustrates "death and the afterlife" with ceremonial and burial artifacts, and it is followed by areas for the major goldworking regions of Colombia. The final section, housed in a separate room, deals with the technology of goldworking.

"The exhibition will be spacious and airy," Appelbaum said. "It's designed with many different needs in mind, has several large areas for teaching, and seats where people can rest.

"The people I want to communicate with are those who usually don't go to museums—who were lured in to 'see the gold.' I want them to have a terrific experience, not a didactic one that makes them feel how little they know. I love the idea of a modern family confronting the rich world of pre-Columbian life. We're not just showing gold; we have a chance to give museum visitors a window to the past, a peek at how earlier peoples interacted with the demands of their daily life.

"But most importantly, I want to communicate the *humanity* of the artifacts—to give a sense of how you relate as a human being to these ancient peoples. The hall will be full of those invisible people who populate any artifact exhibit. I want you to *feel* those ghosts. To *see* them and *know* them. That's what's important."

Robert Goelet first proposed the idea of "Gold of El Dorado" four years ago, shortly after he was elected president of the American Museum of Natural History. His extensive business and personal contacts in Colombia had taken him there many times, and he had been impressed by the collection assembled by the Banco de la República in Bogotá. At his suggestion, the American Museum's staff began negotiating the loan of select pieces in the collection to tour the United States. The extended negotiations involved several bank directors and curators before coming to fruition last year, when the Colombians decided to lend objects from the collection, then on a European tour, to the United States for a period of two years, under the aegis of the American Museum

Thomas D. Nicholson, the director of the Museum, began arranging the terms of the loan, applying for grants, and securing indemnification from the United States government

Perhaps the greatest credit for this outstanding collection and exhibition should go to the past officials of the Banco de la República in Bogotá, Colombia. Some thirty years ago, the great gold objects found by *guaqueros* ("professional tomb robbers") were being smuggled out of the country and sold on the international market. Concerned about this seemingly unstoppable loss, bank officials decided to offer top prices for gold objects, with no questions asked.

By 1963 the bank had stemmed the outflow of gold artifacts and had collected more than 10,000 pieces, from nose rings (which they bought by weight) to beaten and worked funerary masks. To display the gold, the bank created the Museo del Oro, and today more than 26,000 pieces are housed there. Alec Bright, curator of the Museo collection, freely acknowledges the Museo's dependence on the *guaqueros*. "They are of great importance to the history of the 'gold museum,'" he wrote, "because almost *all* its pieces have been obtained from them."

But for some scholars, the bank's noble efforts have caused problems. As Craig Morris, the American Museum's assistant curator of anthropology responsible for South American archeology, explained, "While the bank's heroic collecting efforts have succeeded in keeping the gold together, it cannot replace the information lost in the unprofessional excavations. The unfortunate fact that the stuff is gold and not pottery or flint has meant that we have almost no archeological information about it."

"Gold of El Dorado: The Heritage of Colombia" will be on exhibit at the Museum from November 13, 1979, until March 18, 1980. It is the largest and most comprehensive collection of Colombian archeological artifacts ever displayed outside of Latin America and includes more than 500 gold items and more than 100 pieces of pottery, stone, and cloth. While drawn primarily from

This Quimbaya lime container was cast in tumbaga, a gold-copper alloy. Another lime container in the shape of a human figure (see page 38) depicts how this object may have been worn by pre-Columbian Indians.

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the Museo del Oro, the exhibition also features special items from museums and private collections in Europe and the United States.

After its New York showing, the exhibition will travel to the Field Museum of Natural History in Chicago, the California Academy of Sciences in San Francisco, and the New Orleans Museum of Art. The national tour of "Gold of El Dorado: The Heritage of Colombia" is sponsored by Chemical Bank, with additional support from the National Endowment for the Humanities and the National Endowment for the Arts.

The "Gold of El Dorado" exhibition will be free to the public, after the Museum's discretionary admission charge has been paid. Museum members, who are admitted free to the Museum, will be able to obtain priority tickets. In addition, the Museum plans to have special viewings for Participating and Donor Members.

The Department of Education will offer a special two-lecture series on **Gold of South America.** On December 6, at 7:30 P.M. in the Auditorium, Alec Bright will present a slide-illustrated discussion on the uses of gold for adornment and ceremony. On December 11, Craig Morris will compare the gold of Peru and Colombia and discuss the evolution of gold technology in both areas. Those who attend the series can also see a private viewing of the exhibition from 6:00 to 9:00 P.M. on December 10. Tickets are $20 for the series; a brochure with a ticket order form can be obtained by calling (212) 873-7507.

To complement "Gold of El Dorado," the Museum will open a small exhibition, entitled **It's Gold,** in the Roosevelt Rotunda on November 15. "It's Gold" will explain where gold comes from, how it becomes concentrated in veins, how it is mined, and how we use it. Gold worth millions of dollars will be on display in the form of nuggets, crystals, "good delivery" bars worth $80,000 each, coins, jewelry, and industrial objects.

Discovery Tours

Seven scientists and scholars from the Museum and Great Britain will lead Museum members and friends on a cruise through the British Isles aboard the m.t.s. *Orpheus* in July 1980. Thomas D. Nicholson, director of the American Museum and astronomer, will be host.

Participants will visit such archeological sites as Stone Age dwellings, Roman forts, and medieval castles, and will also observe land and shore birds and flowers.

The motor ship will cruise through the narrow channels of the Hebrides, around the Orkney and Shetland islands, and into the bays of western Ireland.

During 1980, the Museum will offer the following cruises and land tours:

Archeology Tour to Mexico. January 14 to February 3.
Archeology Tour to Maya Mesoamerica. February 16 to March 9.
Nile Cruises. February 17 to March 8, and October 19 to November 11.
Voyage to the Classical Lands (Eastern Mediterranean and Red Sea). February 20 to March 6.
Anthropology Tour to Morocco. March 29 to April 13.
The Galápagos Islands Cruise. April 11 to 23.
Inside Central Asia and Mongolia. May 31 to June 21.
Alaska Wildlife Adventure. June 20 to July 6.
Around Britain Cruises (England, Scotland, Wales, and Ireland). July 2 to 17.
Anthropology and Ornithology Tour to New Guinea and Australia. September 5 to 24.
Arts and Archeology Tour to China. October 14 to November 4.

For itineraries and further information contact Discovery Tours, American Museum of Natural History, Central Park West at 79th Street, New York, N.Y. 10024, or call (212) 873-1440.

Other Events

Dowry Embroideries of Greece, thirty-five embroideries from eight private collections, will be on display in the Education Gallery through January 31, 1980. Dating from the seventeenth to the nineteenth century, these pieces show the artistic influences of the many groups—from the northern Franks to the eastern Turks—that invaded and settled in Greece.

The Art of Scientific Illustration will be on display in the Akeley Gallery until November 26.

Huichol Indian Art will be exhibited in Gallery 77 from November 7, 1979, to February 10, 1980.

Images of Earth from Space will be shown at the Hayden Planetarium until December 16.

Douglas J. Preston

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Hot Butterflies

To get the heat they need for flight, these colorful, winged insects have become consummate sunbathers

by Matthew M. Douglas

Butterflies, being ectotherms, have to gain the heat they need from external sources. To elevate the temperature of their thoracic muscles, which control their wings and legs, they must absorb radiation from the sun or from their surroundings. This thermoregulatory strategy regulates their overall metabolic rate, which in turn controls locomotor activity. Since controlled ambulation and flight ultimately determine an individual's reproduction success, an efficient thermoregulatory strategy is crucial to a butterfly's survival.

I became interested in the behavioral and physiological thermoregulatory strategies of temperate butterflies as a graduate student of insect ecology at the University of Kansas. Many lepidopterists assumed that behavioral orientations to solar radiation, or basking, were thermoregulatorily significant, but others maintained that the various basking positions were sexual displays, warning postures, or concealment strategies. Field investigations by the insect physiologist and behaviorist W. Vielmetter in 1958 showed that one of the European nymphalid butterflies could regulate its temperature by changing the angle of its wings, thereby controlling the amount of solar radiation absorbed by the thorax. Vielmetter concluded that wings were important thermoregulatory structures, but he could not show whether the reduction of wing angle decreases thoracic temperature by reducing the absorption of radiant energy or by altering the convective air currents flowing over a butterfly's thorax. Other investigators hypothesized that blood circulation through the veins of the wings makes them effective physiological heat exchangers (operating much like the water pipes of solar heaters), whose efficiency is affected by modifications of vein structure, color, and pattern.

As a consequence of these conflicting opinions, my objectives were to determine, first, the behavioral and physiological strategies of thermoregulation utilized by butterflies under field conditions and, second, the primary modes of heat transfer, if any, between a butterfly's wings and its thorax.

Perhaps the most amazing discovery of my fieldwork was that virtually all butterfly species, regardless of size and color, require thoracic temperatures of 81°F or higher to initiate controlled flight. The mean thoracic temperature recorded during normal activity for fifty species was 95°, with a range from 82° to 105°. Thus, despite their extremely small weight (0.005 to 1 gram) and ectothermic physiology, butterflies can maintain a range of elevated body temperatures similar to the body temperature range of homoiothermic mammals and birds (90° to 104°), and without the "expensive" basal metabolism of homoiotherms.

Butterflies exhibit five basic thermoregulatory positions: lateral, dorsal, body, and conduction basking, and a dorsally closed position. A given subfamily of butterflies often exhibits a characteristic basking position. For example, the members of the subfamily Coliadinae (sulfurs) are lateral baskers and tilt sideways to present the ventral surface of the hind wings perpendicular to solar radiation. Sulfur butterflies are incapable of basking dorsally with wings fully open, as do most Danaidae (monarchs and their relatives), Papilionidae (swallowtails), and Nymphalidae (anglewings and fritillaries). The Lycaenidae (blues, coppers, and hairstreaks), Pierinae (whites, orange tips), and several genera of Satyridae (browns) are primarily body baskers, angling the wings narrowly so that only the body receives solar radiation. However, several lycaenid, satyrid, and pierid genera are also lateral baskers or alternate between lateral and body basking.

Many species from different families employ conduction basking, in which the body is pressed to a warmer surface and heat is conducted directly to the body. When thermal conditions are too high (not infrequent during a Kansas summer), many butterflies attempt to prevent thoracic overheating by closing the wings dorsally over the

While feeding on nectar, a male monarch is also warming up by absorbing radiation from the sun. He is in the dorsal basking position, the most efficient for rapidly elevating body temperature.

A primitive swallowtail of alpine and tundra regions, Parnassius clodius *is coated with hairs that help reduce heat loss. Here it is body basking while foraging on a thistle flower.*

body and orienting parallel to solar radiation. If dorsal closure of the wings does not reduce the absorption of radiant energy sufficiently, butterflies take cover in heavily shaded areas and cannot be prodded into flight activity.

Butterflies generally are stratified in their flight and basking levels according to their thoracic size. Butterflies of small thoracic diameter generally fly and bask within the protection of vegetation, which may be distributed horizontally, as in a field, or vertically, as in the case of trees. Small butterflies bask for extended periods even under high thermal conditions. These basking periods, interrupted periodically by short rapid flights below three feet in height, usually occur within the physical protection of nearby vegetation. Their flight habits place small butterflies within the relatively stagnant and protective boundary layer of warm air that envelops the earth and vertical vegetation. Within this insulating boundary layer, ambient air temperatures are considerably higher and wind may be negligible, thereby reducing convective heat loss. Thus, small butterflies with high thoracic surface area to volume ratios and concomitantly rapid cooling rates often experience little forced convective heat loss other than that due to flight. Basking within the thin boundary layer also maximizes infrared radiative heat gain from the surrounding warmer air and vegetation, both of which may reach 125°F or higher near the ground.

Butterflies with thoracic diameters between four and seven millimeters inhabit the widest range of thermal conditions, from deep tropical jungles and temperate fields to subtropical deserts and arctic tundras. Several members of nymphalid genera (*Polygonia, Nymphalis,* and *Vanessa*) not only hibernate as adults but also can produce an increase in thoracic temperature of 8° to 10° above the ambient temperature by muscular thermogenesis, a physiological process in which excess heat is produced internally in a manner analogous to homoiothermic shivering. The flight muscles controlling the wings are contracted rapidly and synchronously, producing little visible wing movement but an audible clicking sound as the opposing wings hit each other with high frequency. Because of muscular thermogenesis, nymphalid butterflies, such as the mourning cloak, are often the first to appear in the spring and among the last to fly in the fall. They can also emerge during winter thaws, when they forage on tree sap and decaying vegetable and animal matter.

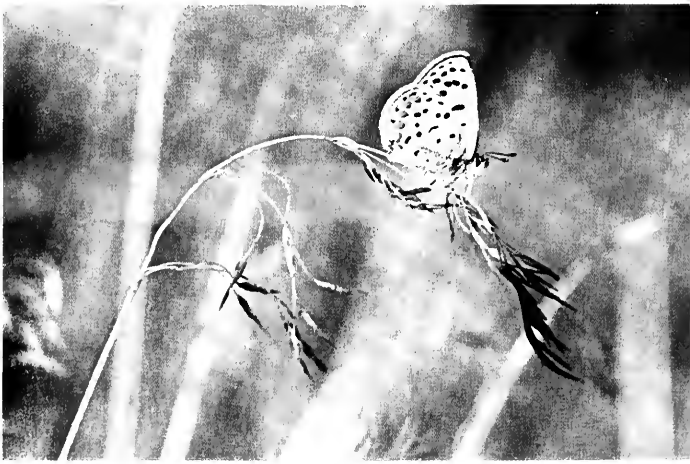
The flight levels and basking periods in these medium-sized butterflies vary tremendously and depend upon the immediate thermal conditions. Many species of the lateral basking sulfurs have evolved a seasonal polyphenism (phenotypic change between generations) mediated by photoperiod cues received during the larval stages. This seasonal polyphenism strategy produces adults with heavily melanized ventral hind wings when the larvae experience the short day lengths of early spring and late fall. By contrast, adults with light yellow undersides are produced upon larval exposure to the long day lengths of summer. Thus, the melanic spring and fall phenotypes are capable of absorbing more solar radiation than their light-colored summer counterparts and can reach the minimal thoracic temperature required for flight under cooler ambient conditions. Similarly, the light yellow phenotypes are adapted biophysically to prevent overheating during the summer months. Some of the sulfur species exhibiting seasonal polyphenism are also seasonal migrators and invade the northern temperate and Canadian zones as spring progresses. This seasonal alternation of phenotypes tracks the expected cyclical changes in ambient temperature and solar radiation, even though only one basic genotype is actually present throughout the year.

Butterflies with thoracic diameters greater than seven millimeters are characterized by large wing spans and slow, gliding flight. The large surface area of the wings of swallowtails, for example, provides tremendous lift for gliding, but it can also be a handicap on windy days. Strong, gusty winds combined with large gliderlike wings moving at a low speed can result in a crash—a serious accident for a butterfly. Smaller butterflies flying within the confines of the earth's boundary layer are not so greatly affected by gusts of wind, and the full complement of lycaenid species can be seen flying a few centimeters off the ground within the protection of vegetation on days with wind velocities of twenty miles per hour or more. Swallowtails often inhabit tree tops where they bask dorsally for fifteen minutes or more under diffuse solar radiation. While dorsal and body basking are the only behavioral

Charles Palek, Animals Animals

Two swallowtails (right and top left), a nymphalid (center), and a skipper (bottom left) have gathered at a wet spot to suck up moisture and salts. The swallowtails are body basking, the nymphalid is dorsal basking, and the skipper is not basking.

An American copper, above, an Acmon blue, right, and a sulfur butterfly, top right, are lateral basking. These small butterflies have the option of basking dorsally. The sulfur is one of the species in which seasonal polyphenism has evolved. Individuals with heavily melanized hind wings are the rule in early spring and late fall. In summer, sulfurs with light-colored wings predominate. The melanic spring and fall phenotypes are capable of absorbing more solar radiation than their light-colored counterparts, a thermoregulatory adaptation to the cool periods during which they live. The lighter summer sulfurs are adapted to prevent overheating on hot, cloudless days.



Fred Herzog

thermoregulatory strategies exhibited for rapid heat gain, these massive butterflies may overheat during the essentially tropical conditions of the temperate summer. However, many danaid species, for example, monarchs, simply do not bask once high thermal radiation levels are reached. Instead, these butterflies close the wings dorsally over the thorax, which reduces the excess thoracic temperature by 70 percent. To prevent overheating, swallowtails continue to flutter their wings while foraging for nectar under high thermal conditions, thereby increasing forced convective heat loss and simultaneously reducing radiative heat gain.

When weather conditions prevented fieldwork, I conducted laboratory experiments to determine the role of butterfly wings in regulating thoracic temperature. I found that living and freshly killed butterflies with the same physical characteristics heat and cool at the same rates and attain the same equilibrium thoracic temperatures. These results suggest that the circulation of blood through the wing veins is not a significant mode of energy exchange between wings and thorax, because dead butterflies cannot possibly circulate blood. In fact, the bodies of dead butterflies provided with artificial paper wings "thermoregulated" as well as living butterflies. The distribution and pattern of wing veins must have little bearing on energy transfer between wings and thorax. It appears that the thermoregulatory significance of wings is due not to physiological mechanisms but rather to the physical presence of the wings next to the body. I reasoned that if wings were important physical structures for thermoregulation, freshly killed butterflies placed in a dorsal basking orientation should show a drop in thoracic temperature when their wings are severed at a stable thoracic temperature and rotated away from the thorax. Butterflies with wings severed and completely removed at equilibrium thoracic temperature experience a 9° to 27°F drop in body temperature within two minutes after the ablation. The actual temperature loss depends on many factors, including the physical size of the butterfly. When these severed wings are reappressed to the thorax (even with incomplete contact with the wing stub bases), thoracic temperature rises again to that of the intact butterfly. So, Vielmetter was correct: wings are important thermoregulatory structures for butterflies.

Temperature profiles of the wing surface show that the basal areas of the wings next to the thorax reach the highest stable temperature, often 105°F under ambient conditions of 68° and solar radiation equivalent to that of a noonday sun. Wing temperatures become progressively lower toward the wing periphery because of increases in convective heat loss.

The basal areas possess the greatest mass per unit surface area and are usually the most melanic and hirsute sections of the wings. In addition, the basal margins of the hind wings are modified into a troughlike structure, which envelops the abdomen during basking. Scale color and pubescence in these basal areas, in combination with the traylike hind-wing margins, were hypothesized to be of the greatest thermoregulatory significance. The experimental results agree with this hypothesis: higher thoracic temperatures are achieved because the properties of the basal wing areas increase radiative heat gain and reduce heat loss from the thorax by convection. The thoracic temperature of scaleless and hairless butterflies is reduced by 15 to 20 percent. Hairiness and microcavitation within the individual scales covering a wing are important biophysical modifications that increase the absorptive properties of the basal wing areas.

Basal wing areas heat three times faster to their equilibrium temperature than an isolated thorax. This increase in heating rate is due to the smaller mass per unit surface area of the wing, combined with the biophysical properties of melanic hairs and scales, which increase radiative energy absorption.

Absorbed energy is then conducted and radiated from the wing bases to the thorax. The physical presence of the wings simultaneously reduces convective heat loss by forming a pocket of insulating warm air between the ventral side of the wings and the surface of the substrate chosen for basking. The temperature of this insulating air pocket is increased when the butterfly is basking dorsally with the wings pressed as closely as possible to the substrate.

Determining the absolute amounts of energy transferred by conduction, convection, and radiation is difficult because altering any variable, such as wing angle, simultaneously affects all of these energy transfer processes. Present estimates are that conduction and radiation of energy from the warm wing bases account for less than 30 percent of the total wing-mediated excess thoracic temperature; the remaining 70 percent is due to the physical presence of the broadly attached wing bases. These wing bases reduce convective heat loss by trapping a warm layer of air next to the thorax and by increasing the effective diameter of the thorax, which in turn reduces convective heat loss by modifying the flow of air around the entire body. Butterflies with wings reduced to stubs corresponding to the basal wing area heat at nearly the same rate and attain the same equilibrium thoracic temperature as an intact butterfly with complete wings. Thus, the outer two-thirds of the wings have little effect on thermoregulatory ability, regardless of color.

It is the proximity of the hairy, melanic, and broadly attached wing bases that endows butterfly wings with their thermoregulatory properties. These wing bases heat significantly faster than the thorax and increase the butterfly's thoracic temperature 30 to 50 percent above that of a wingless creature of the same physical dimensions. The actual percentage contributed by the wings depends upon the basking orientation, the relationship of thoracic diameter to the area of the wing bases, the basal wing color and pubescence, as well as the effects of wind and radiation.

With these laboratory results in mind, one should be able to predict which butterflies will have higher thoracic flight temperatures under field conditions. Butterflies with dark wing bases, for example, should maintain higher thoracic temperatures than closely related species with similar physical dimensions and basking behavior but with light-colored wing bases. Unfortunately, life is not so simple. A comparison of the mean thoracic flight temperatures of two congeneric species—the red admiral (*Vanessa atalanta*), with heavily melanized wing bases, and the painted lady (*V. cardui*), with dusky orange wing bases—indicates that the darker red admiral maintains a mean thoracic temperature two degrees less than that of the painted lady.

At first, these field data seem incongruous with the laboratory results showing that melanic individuals have greater heating rates and attain higher thoracic temperatures at equilibrium than light-colored, size-matched counterparts. This thermoregulatory paradox is solved when the preferred thermal habitats of the two species are taken into consideration. The painted lady is predominantly a field-dwelling butterfly with lower flight levels than the red admiral, which prefers forest edge habitats and exhibits highly variable flight levels. The basally melanized red admiral is better adapted to maintain elevated thoracic temperatures in heavily shaded areas or under conditions when low ambient air temperatures or reduced solar radiation prevail. Conversely, the painted lady is better suited to thermoregulate under high thermal conditions. Thus, the thoracic temperatures accurately reflect each species thermal habitat.

These two species have evolved other physiological and behavioral characters that further adapt them to their environment. For example, the red admiral apparently has acquired the ability to hibernate through the winters of Europe and northern temperate areas of the United States as an adult. By using muscular thermogenesis, this species can take advantage of periodic winter thaws, and it is one of the first butterflies active in the early spring and among the last to fly during the fall. During winter thaws, the adults warm up their leg muscles sufficiently to move from their hibernacula to sunny, protected spots. By contrast, the painted lady migrates south in the fall and north in the spring and is not known to hibernate as an adult in northern areas.

The thermal ecologies of the red admiral and the painted lady differ through the summer months as well. The red admiral commonly is active from sunrise until well after sunset and has been known to be attracted to lights at night. Under the same field conditions, the painted lady does not appear until several hours after sunrise and retires well before sunset. During the early morning and late evening hours, the red admiral utilizes both dorsal and conduction basking on warm substrates, often defending these premium environmental hot spots in pitched territorial battles with other butterflies. During the afternoon when thermal conditions are high, the red admiral shifts its thermal habitat to patches of diffuse sunlight in shaded areas. On the hottest days of summer, individuals can be found resting in window wells, garages, and on the shaded trunks of trees. Under these high thermal conditions, the butterflies cannot be prodded into flight activity for more than a few seconds. By contrast, the painted lady

Fred Herzog

Ralph Williams West Stock

One of the species of butterflies collectively called blues basks laterally as it feeds on a thistle. Such small butterflies fly close to the ground and protective vegetation on windy days.

By pressing itself against a leaf, a skipper gains heat via conduction. Skippers are not true butterflies and are unusual in that they can bask two ways at the same time. The fore wings of this skipper are in a body basking mode and the hind wings are held in a dorsal basking position.

Fred Herzog

does not exhibit territoriality and maintains full activity in open fields by feeding in a dorsally closed position, which minimizes radiative heat gain.

A complex combination of physical, physiological, evolutionary, and life history factors determines the thermal ecology of a given butterfly species. Butterflies are restricted to thermal habitats that best fit their physical dimensions, basal wing pigmentation, inherited basking behavior, and any unique physiological or behavioral factors that directly affect the life history of the species. A totally melanic wing phenotype cannot be explained fully in terms of thermoregulatory significance. Many other selective pressures operating on the color patterns of wings must be taken into consideration: camouflage, mimicry, and specific colors or patterns required for mate identification are some of the most important. Wing base melanization can be a thermoregulatory asset only if the basking behavior allows the pigmented area to be utilized. A lateral basker gains little thermoregulatory benefit from melanic scales deposited on the dorsal basal third of the wings. Similarly, a dorsal basker gains no thermoregulatory advantage by melanizing the distal two-thirds of the wings.

It must be emphasized that many factors affect the total wing phenotype. No single selective pressure alone can be responsible for total wing color and pattern, but certainly, the basal wing areas can be modified for thermoregulatory purposes and must play an important part in the success of these small ectothermic animals. □

The painted lady, far left, is laterally positioned to the sun, absorbing solar radiation from the side. It can also increase its thoracic temperatures eight to ten degrees through muscular thermogenesis, a process analogous to shivering in homoiothermic animals. The checkerspot, left, spends much of its time basking. Butterflies lose heat when flying, so they must perch frequently and assume the basking position most effective for their size and physical configuration. The great spangled fritillary, below, is a dorsal basker active during the midsummer months. Here perched on a red pine, soaking in the dawn sunlight, the fritillary feeds only on violets.

S. J. Krasemann, Peter Arnold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Expected release: Spring, 1980.

Music-making Children of Africa

A Dagomba child learns social habits and personal discipline through music

Text and photographs by John Miller Chernoff

One of the things children everywhere love is music. Take your guitar to a park and begin playing; the first people to stop and listen will be children. Among the Dagombas of northern Ghana, it is the same. "When we are going to a house to play," a Dagomba drummer once told me,

> it is the children who meet us. Some of them will walk with us and lead us; the others will run ahead to inform the whole house, "The drummers are coming! The drummers are coming!" Don't you see that it's nice? It is one way that music adds to us. Music makes us happy, and music shows us things about ourselves, and again, music is something we can pass down to our children.

When we consider the different conditions in which human beings grow up and the role of artistic expression in life, we must acknowledge that "wealth" is an ambiguous word: a measurement of quantity for some people; a reflection of values in human experience for others. The children of the world share a love of music, but African children in particular enjoy the benefits of musical life; they are as involved with music as our children are with television.

In the traditional societies of Africa, children's musical activities are more than recreation. Through music, African children learn social habits and personal discipline. Among the Dagombas, music making gives children a chance to participate in important events, and for some children, musical training also encompasses the study of history and folklore.

Dagomba children begin working at an early age. By the time they are four or five, boys are already accompanying their fathers to the farm, where they may be asked to fetch drinking water or farming implements. In a few years, they can weed and plant. They also care for such domestic animals as cows, sheep, and goats, and they have special techniques for finding food—mainly termites and ants—for chickens and guinea fowls. After a farmer has planted his crops, he may build a treehouse on his plot, and his children and their friends are sent to it every day with *balankon*, a slit-drum made from a hollowed-out log. Their job is to drive off monkeys.

Girls work with their mothers, sweeping the compound, carrying water, cutting and grinding vegetables for cooking, and in season, collecting the shea nuts from which Dagombas prepare cooking and lamp oil. The children's work is difficult, but the Dagombas measure character in the willingness to do hard work, and parents are careful to match tasks with a child's ability and strength.

At night, after eating, the children have no work to do and are free to roam. If they live in a town, they might be given money to attend a movie, but generally they meet with their friends and play. Those children interested in learning more about their tradition sit with old people. It is typical of Dagomba life that people from neighboring houses gather after the evening meal and talk. The children sit quietly to the side; they sometimes massage the legs of a storyteller while he talks: "In the days of such and such a chief, this was what was happening" or "During the war between the Dagombas and the Gonjas, this was what happened." If a child is sitting alone with an old man, he may press the legs and feet of the elder until both man and child fall asleep side by side. In the villages an old man may relax with *jenjili*, a musical bow, or *moglo*, a guitar-like instrument; he sings songs to amuse himself and his grandchildren—songs that tell stories, illustrate proverbs, and sometimes recount history.

A sense of history is central to both Dagomba culture and musical tradition. The Dagombas have an elaborate political system based on hierarchical chieftaincies, and the paramount chief, called the *Ya-Naa*, sits at Yendi, about sixty miles east of Tamale, the most populous Dagomba town. Drummers know the most about history, and at certain times during the year, they sing and beat different parts of the Dagomba drum history outside the house of their town's chief, who sits with his wives and elders while the populace assembles around them. The drummers start in the late evening and play till dawn. The Dagomba drum history resembles no other art form so much as it resembles a Homeric epic.

A young Dagomba boy plays a toy drum. When a boy is about three years old, his father will make him a small drum by simply covering a tin can with skin.

Dressed in traditional hat, smock, and trousers, a young dancer practices his skill to the accompaniment of tribal drums. The dancer's movements cause the smock to bell out gracefully.

Most of the drum history tells of *Ya-Naas* and their accomplishments, lending meaning to Dagomba traditional dances, which are based on the proverbial praise-names of the paramount chiefs of Yendi and the chiefs of other traditionally important towns such as Savelugu and Karaga. Although a typical Dagomba's preference in dancing is not necessarily political, different dances have associations with family origins because most Dagombas trace their ancestry to former chiefs. Not every son of a chief can become a chief, however, and someone for whom the "door" to chieftaincy closed generations ago may still respect his family's line by dancing to the name of a great forefather.

A dance called *Nanto Nimdi* can serve as an example. *Nanto Nimdi* is a praise-name for *Naa Yakubu* (ca. 1850), and it means that meat that has been touched by *nanto*, a very poisonous creature, cannot be eaten or even approached. In addition to obvious respect for the power of chieftaincy, the name implies that whatever a chief's hand touches becomes a dangerous thing; thus the name cautions that citizens should not do anything bad or become involved in a matter that will come before the chief. Drummers beat the name *Nanto Nimdi* and improvise on its rhythm, and people dance to it. Dances such as *Nanto Nimdi* are danced individually inside a circle of spectators. Drummers call a person to dance by beating praise-names of his or her forefathers. A dancer may dance several dances inside the circle, while friends and relatives press coins onto the dancer's forehead or place coins into the dancer's hands. The children of some drummers may dart in and out to pick up the money falling from the dancer and give it to the drummers, who later share it according to status.

In such a context, drummers must possess not only musical skills but also a detailed knowledge of a 500-year-old history and a familiarity with individual genealogies within their communities. Among the Dagombas, therefore, drumming is a professional calling, and to insure the continuity of professional excellence, Dagomba drummers maintain distinct lineage groupings and their own hierarchical chieftaincy organization. Not every son of a drummer is compelled to follow the vocation, although most do so for enjoyment and respect, but every daughter of a drummer must give at least one of her sons for training. Because drumming is knowledge as well as music, the Dagombas say that drumming has no end and that no one can know all of drumming. Each drummer can learn only his extent, and even old drummers characterize themselves as "still learning more." Their main instrument is an hourglass-shaped tension drum; the skins that cover both mouths are sewn to rings of bound reeds and laced with leather strings. A Dagomba drummer secures the drum under his armpit with a piece of cloth, and by squeezing the drum, he can produce notes ranging more than an octave. Commonly known as a "talking drum," this instrument is played in many West African societies. Dagombas call it *lunga*. The bass beat is provided by *gungon*, a large tom-tom with a thin leather string that acts as a snare; like *lunga*, it is hung from the shoulder.

When a drummer's wife gives birth, he takes his drum outside his house and beats praise of God and of the chiefs of Yendi. When the child is about three years old, his father will make a small drum by attaching two half calabashes back to back or by simply covering a metal can with a skin. At age five or six, a child is given a small version of

The beat for the dancing woman is provided by gungon, *a large tom-tom hung from the shoulder. Like the smaller drums (at right),* gungon *is played with a curved wooden stick.*

lunbila, the small-sized *lunga*, and among the first things he is taught to beat are the proverbs every drummer beats when picking up a drum throughout life: A bachelor is a child, and a married person is the elder; the person who has an owner will eat, and the person without an owner should sit down; the person who says there is no God should look to his front and his back (his ancestors and children).

Next the child learns to beat the names of his parents, grandparents, great-grandparents, as far back as his father knows. From his family, the child moves to the names of the past chiefs of Yendi up to the present, and after learning the Yendi chiefs, he progresses to the chiefs of other important towns such as Savelugu, Karaga, Mion, Kumbungu, Tolon, Tamale, Nanton, Gushegu, Voggo, Sunson, and also the chiefs of villages in his area. When a child is about ten years old, he will accompany drummers to functions, carrying their drums for them. There the drummers' children collect money from the ground and also learn to recognize the various people of their community and how the drummers praise each of them with the drum. In a few years the young drummers can begin beating and following the other drummers. By the time they are teen-agers, they may get *lundaa*, the medium-sized *lunga*, and they are distinguishable in the extent of their knowledge. When they meet their contemporaries at functions, they bluff each other. One young drummer will beat the chiefs of Yendi and Savelugu, only to be embarrassed when another youth follows him all the way and then goes on to beat Kumbungu and other towns.

Learning drumming is difficult work, and the Dagombas say that if a person's heart is not in it, he will not learn. In describing the act of beating alone, Dagombas say that it is the heart that talks and the arm that does what the heart wants; only a child with a "bright heart" can gain wisdom. In the evenings, drumming children go to their master and massage his legs and feet while he lectures to them and teaches them singing. Some children learn everything easily; Dagombas say that these are "born with a drum." Those who are unwilling learners may be beaten or knocked on the head with a drumstick to motivate them. Some drummers can display scars on the top of their head; they remember their suffering but are happy that their masters did what was necessary, for they treasure the satisfaction their eventual mastery has given them. Beatings are not common, however, and children without talent or desire are generally left to achieve their own level.

Typically, young drummers reach the highest standard by traveling to different towns and staying with great drummers. There is no charge for the teaching, but a young drummer gives his elder many gifts when he has finished learning from him. Dagombas say that two wise people cannot stay together; to learn drumming, therefore, one should make oneself a fool, put aside what one has already learned, and add the knowledge that the master can give. For the Dagombas, wisdom comes from saying, "I don't know," and then asking. Dagomba drummers do not reveal their hard-earned knowledge to those who are not serious, and to learn drumming requires patience and respect. Because drumming has no end, drummers move into maturity with the promise of continued growth in the practice of their art and the appreciation of their heritage.

Drumming by traditional drummers, however, is not an everyday occurrence but is reserved for events such as weddings, funerals, festivals, the installation of chiefs, and the public "outdooring" of newborn babies. Besides drumming, such events are likely to feature the music of *goonji*, fiddles with strings made of hair from a horse's tail. The music of fiddlers is given an extra punch by a number of gourd rattles in cross-rhythmic accompaniment. Fiddles were introduced into the Dagomba tradition about two hundred years ago, but unlike drummers, fiddlers do not restrict entry into their profession by family origin. Although not as knowledgeable as drummers, fiddlers also sing songs of praise, and children who learn fiddling follow an apprenticeship that involves singing and rattle playing as a prelude to learning the main instrument.

The participants at social functions relate to the beat of drums and the tune of fiddles by dancing, and Dagomba children learn their traditional dances by watching and later practicing when they meet their friends to play in the evenings. The children are such avid fans of music that they think nothing of setting out after dinner and walking several miles to a neighboring village if there will be drumming and dancing to watch. Often, when the children return in the early hours, they find the doors to their houses locked because their parents have assumed that they fell asleep at a friend's house. Afraid to wake up the neighborhood by knocking on the door, the children climb over the walls of the compound. Climbing over the walls of their houses after musical events is something older Dagombas recall fondly as a part of childhood.

Dagombas who remember their childhood love of music often organize occasions for their own children to dance. *Tora*, *Takai*, and *Lua* are three popular dances for children and young people.

Tora is a dance for girls. The girls stand in a line, and two jump out in opposite directions, then turn and run toward each other, knocking their buttocks when they meet; the first girl out goes to the end of the line, and a new girl comes out to bump the second. Our teen-agers may think that the "bump" is a new dance, but Dagomba girls have been doing it for more than a hundred years. Much of the drumming for *Tora* is the same as the drumming for *Takai*, a dance for young men and boys. The *Takai* dancers knock sticks or metal rods as they spin in alternate directions in a circle around the drummers; their traditional smocks bell out as they turn gracefully, offering a lovely spectacle. *Lua* is an athletic dance in which girls form a small circle, and one girl dances in the center. When the drummers reach a certain rhythm, she runs to one side of the circle, where three girls pick her up and throw her in the air so that she lands at the other side of the circle.

Baamaaya is probably the beat that Dagomba children first learn to recognize, and it is especially popular when mosquitoes are out in force. *Baamaaya*'s meaning is that mosquitoes should not find a place to rest, and *Baamaaya* dancers twist their waists continuously as they circle around the drummers. Metal shakers on their ankles add complementary beats to the drumming, and they wear striking headdresses and earrings and also carry fans that they use while dancing. I tried to dance *Baamaaya* once, but I sat down in minutes, my stomach knotted in pain, and I had to content myself with watching the others while I swatted at what seemed an inordinate number of mosquitoes, which had, I suppose, no other place to land.

Many Dagombas continue to dance *Baamaaya* or *Takai* into their adult lives, but young people also organize their own type of music, called *Simpa*, through neighborhood clubs. Club members pay dues and may be fined for missing rehearsals or performances. A tourist on an evening stroll in a Dagomba town would have a good chance to meet different *Simpa* groups practicing for one of their competi-

tions, singing songs with flute or harmonica and drum accompaniment. *Simpa* originated about fifty years ago from a Kotokoli dance called *Gumbe*, but the young Dagombas have transformed *Simpa* into an eclectic style that includes high life, rumba, soul, merengue, blues, bossa nova and other generic beats. Different groups use different types of instruments, from traditional Dagomba drums to sets of square-frame drums to sets of conga and jazz drums fashioned of metal by local blacksmiths. In an active *Simpa* club, members come every evening to sing in the chorus. The songs are often based on Dagomba proverbs, but the singers also comment on community issues and satirize rival groups. The dancing is done by twelve- to fifteen-year-old girls who come out, one or two pairs at a time, to dance matching, studied steps with intense concentration. *Simpa* groups usually participate in Dagomba funerals, and newly installed chiefs call them to help the young people celebrate.

Simpa styles are diverse and open to influence and change. In recent years, popular movies from India, romantic musical fantasies, have caused a sensation among young Dagombas, who remember the songs and set their own words to them. The melodies also provide inspiration for long improvisations on plastic flutes. To fit the music, one young Tamale man called Ali Bela, after the swashbuckling hero of some of the films, created a new style of drumming, using the fingers of one hand on different parts of the bottom of a five-gallon oil drum while using

Surrounded by curious young spectators, above left, Atikatika children practice for one of their competitions. The metal drums are made by local blacksmiths. Two Dagomba girls, above, "bump" while dancing Tora. The one on the right will rejoin the line, while in the background, another dancer prepares to step out. Left: Pressing coins onto the forehead of a dancer is a sign of respect and appreciation. The infant on the back of one of the women is no doubt absorbing, indirectly, some of the excitement of the occasion.

A Dagomba chief arrives at a festival. The elaborate decorations on the horse are made of leather. The Dagombas are great horsemen, and typically, horses are taught to "dance" to the beat of drums.

the other hand to play accents on the rim with an empty can of evaporated milk. The music is beautiful, and I was impressed by the notion of walking in the streets of Tamale and coming across a musical group with a name like Bombay, singing Dagomba homilies fitted to Indian tunes, with instruments acquired from Western oil companies and food processors and from Asian toy manufacturers.

But it is the small children who have most recently astounded Dagomba society with their musical inventiveness. *Atikatika* is a new dance that started in Tamale and swept through the other towns. A few young adults help the *Atikatika* groups solve organizational problems, such as acquiring uniforms and arranging transportation, but it is the children who plan the music, songs, and dancing. The children, of course, are true believers, and only rain—or an Indian film—can make them miss their nightly practice. The drummers are boys eight to ten years of age. The dancers, boys aged from four or five to eight, dress in white singlets with matching colored shorts and beanies; they tie metal shakers to their ankles, and dance precision acrobatic steps in a circle, using the shakers in various ways to cross the heavy, characteristic 12/8 beat of the drums. The chorus of young girls is led in high-spirited singing by an older girl, perhaps in her early teens.

Because the *Atikatika* children sing witty political songs, they are often in trouble with local authorities, who periodically ban their music. The chil-

Baamaaya *dancers begin their dance, which can last several hours. Besides drums, the* Baamaaya *beat calls for flute and rattles. Metal shakers on the dancers' ankles add a complementary beat.*

dren respond by planning new songs and dance steps and starting up again—only to be banned again. Some songs abuse pretentious prominent figures or are obscene commentaries on adult hypocrisies; sometimes, they resemble "children's rights" manifestoes, featuring complaints about such matters as being given yesterday's food.

Atikatika began during the political and social turmoil that followed the overthrow of the Nkrumah regime in 1966 and, on a local level, the escalating crisis in a continuing dispute over the Yendi chieftaincy. Many of the old people who object to *Atikatika* feel that the inflammatory songs the children sing are contributing to current problems, but *Atikatika* is popular with young people who consider themselves modern. Many young people, alienated economically or disturbed by the inequities of the modernization process, encourage the children to continue speaking out through their provocative, humorous songs and dances. When an *Atikatika* group practices, young spectators gather to be entertained, waiting to see what new things the children will do next; many old people stay away and mutter among themselves, until they take action.

Whatever happens in the future to change Dagomba society, music and dancing will continue to be a vital part of Dagomba life. Dagomba children will continue to learn their traditional dances and to find musical means to express their ambivalence about the world in which they are growing up. Music, for them, is a source of continuity in their own lives, a link to the past and a path to the future. Older Dagombas, even those who look at *Atikatika* and wonder what today's children are coming to, acknowledge that children give meaning to tradition. As one Dagomba told me:

> If you want to see our way of life, you will see it from the children. Even when we watch them play and we watch how they are with each other, we know how they will end up. So it is the children who make our culture, because the children can do something and it will come to stand as something for the old people. All our old dances, the children didn't start them, but when children play, they dance them. And the new dances we have not seen before, it is the children who started them, and when these children grow up, these dances will become an old thing to them. And so, as for our way of life, it all starts from the children. □

Coconut Crabs and Cannibalism

Sporting claws that would make some lobsters blush, a coconut crab does not need coconuts to survive

by Gene S. Helfman

Tropical atolls develop largely through the accumulation and deterioration of storm-tossed coral boulders. Their flora and fauna evolve slowly and by chance events. Immigrants arrive on floating logs and other flotsam, on air currents, attached to birds, or in the form of pelagic larvae. Once on the atoll, colonizing animals rely to a great extent on food carried by tide and storm, either in the form of dead or dying marine life or fruits and seeds. Many plants germinate from floating seeds that are resistant to saltwater, have passed successfully through the filter of hungry shoreline animals, and are tolerant of the poor soils. They develop into the relatively simple vegetation typical of most atolls, and their sporadically produced fruits and seeds will, in turn, supply the animal inhabitants with food. That the fauna of tropical atolls is characterized by opportunistic omnivores is therefore not surprising; among the most successful on these atolls are hermit crabs.

Hermit crabs conjure up an image of ubiquitous small crustaceans in acquired snail shells jostling one another in tide pools. While this image holds on tropical shores, the fifteen species in the family Coenobitidae have successfully adapted to terrestrial existence and capitalized on the variable resources of atolls. Most of these crabs play their traditional roles, scavenging for beach drift and engaging by day and night in a repeated exchange of snail shells. In fact, the name Coenobitidae is derived from the Greek *koinbios* ("living together"), a term applied to communal monastic orders. One species, however, has departed from the script in several significant aspects and is, to quote Darwin, "as curious a case . . . of adaptation" as will be found among the many intriguing organisms that inhabit atolls.

The coconut, or robber, crab, *Birgus latro*, is a typical hermit crab throughout the initial stages of its life. Females release their larvae into the sea, where they become members of the plankton community for about a month. Then, as postlarvae, or glaucothoes, they settle to the bottom. At this stage, they are indistinguishable from the glaucothoes of other coenobitid hermit crabs. After a period of further maturation, they pick a small snail shell, and emerge onto the shoreline as small crabs. Here, they compete with the young of other hermit crabs for food and snail shells, increasing in size and changing shells with each molt. But the similarity ends at this point, for when it reaches a size of less than one inch across the carapace, the coconut crab gives up the shell carrying habit of its hermit crab ancestors and thereby opens up new possibilities and problems in its terrestrial existence.

A coconut crab and a coconut on Naitamba Island in the Fijis. Although the crabs are known to eat the meat of this fruit of the coconut palm, there is no reliable evidence that they can remove the tough, fibrous husks.

Keith Gillett, Tom Stack and Associates

Gene S. Hellman

An intact snail shell is essential to the existence of a terrestrial hermit crab and serves a multitude of purposes. It provides shelter from predators: a threatened crab pulls in its body and legs, seals the aperture with its broad claw, and presents a relatively impenetrable defense; and the internal helixes of the snail shell effectively trap a small reservoir of water, which keeps the crab's gills moist, prevents desiccation of the permeable skin, and provides a marinelike environment for the eggs that the female carries on her abdominal appendages.

The body of the average hermit crab is typically soft, asymmetrical, and twisted to fit into a spiraled gastropod shell. A coconut crab's body, by contrast, is firm, symmetrical (except for the unequal claws), and linearly arranged. Without a snail shell, the coconut crab must avoid desiccation by shunning the tropical sun. The crabs therefore spend their daylight hours resting in burrows that they dig under logs and tree roots, and their scavenging activity is almost entirely limited to the nighttime. In many respects they treat these burrows much as other hermit crabs treat their snail shells: a burrow is the domain of a solitary crab and usurpers are rebuffed with aggressive displays. As they increase in size, crabs inhabit larger burrows. When threatened, a coconut crab retreats into its burrow, wedges its legs against the burrow walls and, in some cases, even seals the entrance with a claw.

Burrows eliminate the problem of finding and transporting a series of increasingly larger and heavier shells. Hermit crabs stop growing if they do not have larger snail shells to move into; consequently, many species have evolved into minute forms to take advantage of the greater availability of small shells in most habitats. As a snail shell grows, its weight increases faster than its capacity to hold a hermit crab, which means that a crab must allocate considerable energy for carrying and balancing the shell. This seems to have set an upper limit on the size that hermit crabs attain. Having abandoned its snail shell, the coconut crab does not have these constraints on growth. As a consequence, it grows to relatively gigantic proportions: crabs weighing seven pounds and measuring three feet from leg tip to leg tip are not unusual. The coconut crab is, in fact, the largest terrestrial arthropod extant.

By inserting one of its legs into the eye hole of a rotting coconut, a crab manages to scrape up a bit of the meat within. Many Pacific atolls are strewn with rotting coconuts on which the crabs can feed.

The claws of the coconut crab are formidable. The larger, left claw has molariform "dentition" for crushing. Incisorlike dentition for biting and scooping is a feature of the smaller, right claw.

Keith Gillett

With an increase in size has come increased strength, and this strength gives a coconut crab a competitive advantage over the other omnivores on an island. On numerous occasions I have seen the competition—other species of land crabs, hermit crabs, and rats—abandon food with the approach of a coconut crab. These other animals seldom return to the food before the coconut crab has finished. If they do, they are successfully repelled by a lifting of one of the crab's first walking legs, a threat directed at most intruders, be they crustacean, rodent, or human.

During interactions over food, the coconut crab shows its individualistic nature. Most hermit crabs feed communally, at least to the extent that several will dine on an item with only a minimum of pushing and shoving. In coconut crabs, however, feeding is strictly an individual activity. If the food item is small enough, the crab will drag it to a burrow and eat in relative peace. But if the food is for some reason immovable, the crab will probably have to defend it during the course of its meal, and then one can observe an advantage of large size in this species. There is one dominant rule in coconut crab competition: the larger crab wins. I have never seen a smaller crab displace a larger one at a food source, and only once have I seen a larger crab fail to displace a smaller one. When approaching a larger crab that is feeding, a smaller crab will generally stop about three feet away and retreat hastily at any quick movement or leg display by the larger animal. A feeding small crab will usually yield the food item and retreat when a larger crab approaches within three feet. "Individual distance," a characteristic of many animals, is maintained entirely through the vigilance of the smaller crab of an interacting pair. Such asocial behavior contrasts sharply with the gregariousness of most other hermit crabs.

There are other striking differences between the sociobiology of the coconut crab and its shell-carrying relatives. Most hermit crabs, for example, utilize the leg lift, or "ambulatory raise," display during aggressive interactions. The coconut crab performs a homologous display, but the pattern differs in two intriguing respects. First, the ambulatory raise of the coconut crab is exaggerated; the leg is raised much higher over the body than in any other hermit crab. Second, ambulatory

raise is the predominant display used by the coconut crab in a number of agonistic situations; most other hermit crabs have a variety of leg and claw raises and extensions that are used under various circumstances. These differences in display may have resulted from an interplay of ecological and behavioral forces that accompanied the loss of the shell-carrying habit.

For the coconut crab, independence from the gastropod shell brought about an increase in size and strength and a predominantly nocturnal activity pattern. But with greater strength came an increased likelihood of injury when two crabs fought. Selection favored those crabs that were able to keep distance between themselves and other individuals. One mechanism for maintaining this distance is some form of unmistakable behavioral display to communicate the distance-maintenance message; the simpler the movement and the smaller the behavioral repertoire involved, the less chance for confusion or misinterpretation. But the coconut crab had to draw on its hermit crab inheritance of visually-mediated agonistic patterns, such as the extended claw display utilized by many hermit crabs during aggressive encounters. In this display, the claw is held out directly in front of the hermit crab's body and parallel to the ground. Such a movement would be exceedingly difficult for the nocturnal coconut crab to see and could lead to ambiguity. Through natural selection, these confusing patterns were apparently eliminated from the behavioral catalog of the crab. Instead, selection favored the retention and exaggeration, or "ritualization," of a less confusing display that could be seen at night. Ambulatory raise would be such a display because it involves lifting a leg above and away from the body, perhaps taking advantage of the back-lighting characteristic of nocturnal conditions and thereby outlining the displayed leg against the night sky.

A simplified behavioral repertoire and a basic asociality extend even to the coconut crab's sexual behavior. Most hermit crabs engage in lengthy courtships that may last hours or even days. During this time, the male may literally drag the female around, and both partners engage in a series of tapping, picking, rubbing, stroking, and jerking movements. Mating in the coconut crab is a quick, simple, and infrequent event—so infrequent that in the hundreds of hours that field re-

Gene S Helfman

searchers have spent studying the crabs, it has been seen only once. On that occasion I witnessed most of the sequence, which lasted fifteen minutes; at the end, the crabs couldn't get away from each other fast enough. Interestingly, the male of the copulating pair was larger than the female, one instance where the coconut crab conforms to the usual circumstances for a hermit crab.

Size-related differences are shown in other aspects of the crab's biology. On Igurin islet at Enewetak (Eniwetok), most crabs are capable of traversing the entire islet during a night's foraging. However, large crabs inhabit what appear to be the ideal parts of the island—areas with sandy soil and abundant coconut palms. Sandy soil is the best for digging burrows, which are important when a crab molts and goes through the vulnerable soft-shell stage. Smaller crabs are more typical on the rocky margins of the island, living in the interstices of the coral boulders thrown up by storms.

To my knowledge, the crab has no significant natural predators, at least not after it attains sexual maturity at a size of about two inches across the carapace. I have heard of one instance, in the Palau Islands, of a marine crocodile that had eaten a coconut crab, but these two species only co-occur in the Indonesia-New Guinea region, while the coconut crab is found throughout most of the tropical Pacific and Indian oceans.

Introduced enemies are another matter. Pigs, rats, and even monitor lizards and monkeys have been implicated in coconut crab predation, although, again, their effects must be felt most strongly by the younger crabs. Human predation is significant on many islands and has been responsible for localized extinction in several areas. Islanders consider the crab a delicacy, particularly the claws (which taste like a sweet lobster tail) and the fat storage area of the abdomen. The crabs are lured with staked, or tethered, opened coconuts, which the crab hunters check periodically during the night. A feeding crab is quickly, but carefully, dislodged from the bait and thrown into a burlap sack. Each captured crab must be covered with a layer of leaves that acts as a buffer zone between it and the next crab tossed into the bag. After each trip along the bait line, the bag is emptied and the crabs are strung up with vines or sennit rope to prevent contact be-

Like clawed spiders, captured coconut crabs hang from a pole at sunrise. Pacific islanders tie the crabs in this manner to prevent them from fighting with, and dismembering, each other.

Coconut crabs are the largest living terrestrial arthropods. Individuals the size of this one, here eating a frog, may be more than thirty years old and are almost always male.

Zig Leszczynski, Animals Animals

tween them. Forcing two coconut crabs together invariably results in the smaller being killed.

While it may be the best bait, coconut is not an essential food item, and crabs are successful on many islands that have no coconuts. The coconut crab will apparently scavenge anything organic, and its diet can only be described as catholic. Food items include the fruits of most island plants, decaying leaves and wood, soil, and carrion. E.S. Reese of the University of Hawaii once saw a crab pounce on and dismember a tern that, momentarily dazed by a flashlight, had become entangled in the undergrowth. The crabs also feed on recently molted shore crabs and on the molted exoskeletons of other crustaceans. The latter probably provide calcium for growth and thickening of the carapace. This exoskeleton feeding habit created practical problems for the islanders resettling Bikini and Enewetak more than a decade after the nuclear bomb tests of the 1950s. The crabs are so efficient at utilizing available nutrients that they eat their own exoskeletons following a molt, thereby recycling their calcium stores. Unfortunately, this led to a recycling of radioactive strontium, with

the crabs remaining hot long after radiation on other parts of the islands had returned to acceptable levels.

And, of course, the crabs eat coconuts. It was the alleged coconut-opening ability of the crab that fascinated early European travelers to the Pacific. Second- and third-hand reports contained in many ships' logs, chronicled by Darwin and others and included today in university textbooks, describe how the crab is purportedly capable of climbing a coconut palm, snipping off a nut, retrieving it on the ground, removing the husk, carrying the nut back to the tree, and then dropping it on the rocks below. The final steps in this pattern are supposedly repeated until the nut breaks open. An unsubstantiated alternative process is discussed in an 1876 treatise on tropical life by Dr. G. Hartwig.

> According to the observations of Messrs. Tyerman and Bennett, the well-known missionaries to the South Seas, the Robber Crab has another method of getting at the cocoanut, and displays an instinctive knowledge of political economy which is remarkable. "These animals live under the cocoa-nut trees, and subsist upon the fruit which they find upon the ground. With their powerful front claws they tear off the fibrous husk; afterward, inserting one of the sharp points of the same into a hole at the end of the nut, they beat it with violence upon a stone until it cracks; the shell is then easily pulled to pieces, and the precious fruit within devoured at leisure."

In truth, the nut-opening method of the crab remains fascinating—and unknown. No one has published in the scientific literature an account of nut opening or a photograph of a crab in the process of opening a nut. I am convinced, however, that the crabs can do it, since I have found piles of coconut fiber and observed crabs walking around with husked, opened nuts in places where I was the only other possible coconut husker. Someday, someone will be patient and fortunate enough to witness and photograph the entire process.

With or without an ability to open coconuts, the coconut crab finds itself in a favorable ecological position—it leads a relatively predator- and competitor-free existence for most of its adult life. The isolated geographical distribution of the crab, along with its insular, terrestrial habits, has contributed to this situation. Small, remote atolls are typically lacking in large animal forms. The usual means of dispersal for other animals, such as riding sea currents on logs or being carried aloft by the wind, become increasingly useless as the size of the animal and the distance between stopping places increase. No other animal on tropical atolls approaches the coconut crab in size.

But evolution involves compromise. Without significant competitors and predators, the coconut crab is faced with a number of evolutionary tradeoffs. For example, competition and predation are two conventional means of population regulation no longer available to the crab. Another typical population relief valve is migration, but studies by the late W. J. Gross of the University of California, Los Angeles, have shown that the crab is unable to survive for more than a few hours in seawater. Hence migration is not an alternative. Parasitism is an additional cause of mortality, but the remote distribution of most crab populations has apparently served as an effective barrier to the evolution of coconut crab specific parasites. The last obvious means of population control would be some form of feedback from resource availability to reproductive rate. As a population of crabs increased in size, it would reduce the availability of food and burrow sites on the island, which might then stress the reproductive machinery of the individuals and slow the production of young. But even if it were to evolve, this mechanism would do little to curtail the recruitment rate of new crabs, since recruitment is from the planktonic larvae, most of which are probably produced on other islands. Consequently, an already overcrowded crab population may find itself bombarded with young crabs produced on another island. The dominant animal in any food web cannot afford to increase unchecked. Part of the coconut crab's solution to overcrowding is rather straightforward: it eats its own kind.

There is much evidence that strongly implicates the coconut crab in cannibalism. Several of the early European explorers remarked on how quickly coconut crabs "fell upon" injured conspecifics. Our attempts at keeping crabs in confinement have inevitably resulted in the largest crab killing and eating all the smaller ones. Native crab hunters have learned from experience that captive crabs must be kept separated or the large ones will kill the smaller ones. More convincing is my observation of large crabs carrying, fighting over, and feeding upon a dismembered but living smaller crab. This observation has been repeated in the Andaman Islands by R. Altevogt and T.A. Davis, who have also experimentally induced cannibalism by tethering live crabs and watching free-roaming individuals attack and eat them. All these observations support the contention that cannibalism may serve the dual purpose of keeping large crabs fed and the population under control.

The need for opportunism in a situation where food availability changes with the wind and tide is evident. If opportunity comes in the form of a crab that has been injured by a storm-loosened coconut or a small crab that lets its guard down while scavenging for dead fish in the beach wrack, then it is an opportunity to be grabbed. Can such opportunism—to the point of destruction of conspecifics—be explained in the framework of evolutionary theory? A phenomenon such as cannibalism could be expected to arise in a situation where the victims were produced in another breeding population and therefore shared little genetic similarity with the predator. This appears to be the case with the coconut crab. Additionally, new recruits may even lower the reproductive potential of the resident crabs because the new arrivals will decrease the important resources on an island to the disadvantage of those crabs that are already capable of reproducing. For several reasons, it could be selectively advantageous for a large crab to prey upon its smaller competitors.

Realizing, then, that a competitive encounter between two crabs over a food item can result in the death and consumption of the loser explains much about the peculiar behavior of the coconut crab. This understanding helps explain the evolution of the extremely one-sided nature of competition between different-sized animals, the spatial separation of large and small crabs, and the asociality of this species. Few sit comfortably at a table set for cannibals. □

Threatened by the presence of researchers conducting a population study on Enewetak Atoll, this coconut crab has climbed a Pisonia *tree stump. Climbing is a common response to sensed danger.*

ene S Helfman

Pere Mourns Margaret Mead

One year ago, a village that had welcomed the anthropologist as a friend gave her its final farewell

by Barbara Honeyman Roll

When Margaret Mead left Pere village fifty years ago, the slit-drums sounded the tattoo for the dead and the people mourned. Neither she nor they expected her to return to Manus Island. But she did return, twenty-five years later, to observe and record the unprecedented, rapid cultural transformation that followed the islanders' conversion to Catholicism in the 1930s and World War II. In all, she returned six times. No longer were there tattoos for the dead when she left, but the farewells were still like deathbed scenes. As she said, "Each time there was no way of predicting whether I would ever be able to come back."

On November 15, 1978, the Papua New Guinea National Broadcasting Company relayed the news that Margaret Mead would not be coming back again. Pere closed its school, and all the people in the village went into their houses for twenty-four hours of mourning. Twenty-six women who had known her well went to the house that had been built for her in 1965; there they stayed for five days and nights, singing dirges for the dead. On November 22, the councilor (mayor) of the village sent us a cable: "People sorry of Margaret Mead's death. With sympathy, respect. Rested seven days. Planted coconut tree memory of great friend."

Margaret Mead had hoped to return to Pere in late December 1978; perhaps she wanted the end to come in the field. Instead, three of us who had worked with Margaret and visited Manus with her (Theodore Schwartz, professor of anthropology at the University of California, San Diego, my husband, Fred Roll, and I) went to Pere three weeks after her death. We felt that we should be there to share the sorrow and mourning of her friends, who could not come to us to pay their respects.

When we arrived in Lorengau (population about 2,150), the provincial capital of Manus, we were greeted by a delegation from Pere, led by the councilor, Francis Paliau. He suggested that we spend an extra day in Lorengau to give the village enough time to prepare for our arrival. We knew there would be special ceremonies mourning Margaret Mead. In the course of a half century, she had become a valued and wise friend, almost an ancestor of *lapan* ("noble") rank.

The solemnity of the Pere delegation suggested the grief felt by the people of the village. Francis Paliau added to the gloom when he told us that John Kilepak (often called "JK") was very ill with a swollen leg and had been in his house ever since he heard of Margaret's death. We were greatly worried, for we knew how much John Kilepak must have been affected. In 1928, he was the leader of the five teenage boys who ran Margaret's house. The heir apparent to the most powerful and aristocratic clan in Pere, John Kilepak has remained a dominant figure in a greatly changed culture. When Mead and Schwartz arrived in 1953, JK was the master canoe builder and the best canoe captain on the Manus south coast. He was also a chief informant, consultant, and valued aide to Margaret and to us on our visits to Pere.

While we were in Lorengau, Ted Schwartz was asked to give an interview on Radio Manus, to be broadcast on the evening news. He spoke in classic neo-Melanesian pidgin, explaining the work of anthropology on Manus. He told of Mead's friendship for the Manus, of her having brought him there the first time in 1953, and of the great loss occasioned by her death. We later found out that almost everyone with access to a radio (and that is a good-sized part of the Manus population) listens to the news every night and had heard the interview.

Two days after we arrived in Lorengau, we set out by canoe on the twenty-mile voyage to Pere. As we crossed the reef about a quarter-mile from the village, we could see that almost all the people in the village (about 500) were gathered on the beach. From a flotilla of a dozen canoes arranged in two parallel rows, women stood waving bundles of croton leaves, while the death tattoo was sounded on the slit-drums. With the easy eclecticism that blends the traditional with the modern, the Pere people had also assembled the school children in their best clothes to greet us on the beach. They sang in English a song composed by their schoolteacher. With it they welcomed us to their "lonely" village and spoke of us as "homesick" for our own land, perhaps imagining how they would feel so distant from their own village. We stepped ashore and were led across the "village square" to a new, still unfinished community center. As we walked, we shook hands with sad-faced men, embraced women who sobbed, "Oh, Margarit, Margarit, i dai pinis [she is dead]," and touched the reaching hands of silent, wide-eyed children. We were ushered into the

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new hall to a table set with tea and biscuits to refresh us.

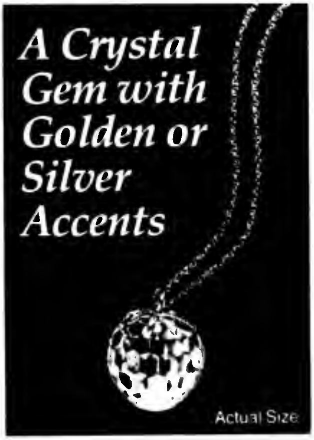
The adults crowded into the building, where they sat on the concrete floor or leaned against the walls. The small children sat on their parents' laps or were held in their arms, while the larger children and young adults filled the empty doorways and peered in through the big open frames, not yet fitted with windows. We felt a momentary lift of spirits when we spotted John Kilepak at the back of the hall, leaning on an improvised cane, standing beside his childhood friend Petrus Pomat, the only other survivor among Margaret Mead's five boys.

Francis Paliau welcomed us and thanked us for coming to them. He eulogized Margaret in pidgin, saying that her Pere friends would like to know how long she had been ill, where she had died (at home? in the hospital?), the cause of her death. In the village, everyone knows in detail the progress of every illness, its apparent seriousness, and the intimate circumstances of death. Paliau tried to let us know that the village mourned for Margaret just as if she had died in her own house in Pere, where the wailing chants for the dead would have begun the moment her attendants had acknowledged her death.

Schwartz replied with a moving eulogy (also in pidgin), explaining that Margaret had died of a cancer for which there was no surgery or treatment that could have cured her. He reviewed the history of her many visits to Pere and of our visits to Pere with her. He spoke of her friendship and affection for the people of Pere, of her feeling of closeness to them, and of our own sorrow and sense of loss. And he gave an account of her last visits with us. It was a heartfelt response to the rapt attention of the audience. We then presented to Francis Paliau, for the village, a mounted color photograph of Margaret Mead surrounded by a group of her friends in Pere on her last visit there in 1975. The photograph was held aloft for all to see and then passed from hand to hand until each person had looked at it.

Barbara Honeyman Roll

Standing on canoes, women mourners meet their guests from overseas



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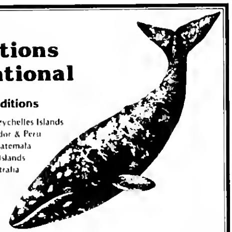

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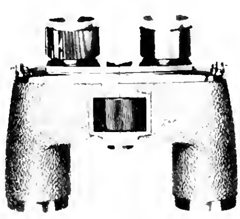

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Fred Roll

Josep Bopau and John Kilepak demonstrate the tattoo for the dead.

After the ceremonies at the community center we went across the village square to our house—Mead's house—a traditional, palm-thatched house, which looks out on the reef and the nearby islands. The village leaders and a group of women came with us and filled the house. Francis Paliau called for silence. He spoke about the special customs that were being observed to mourn the death of Margaret Mead, a person of great importance. He told us that the "haus bilong Margarit," where she had lived on four visits to Pere, was chosen as the house of mourning, the house of death. The chief, official mourners, self-selected, were women who were entitled by their importance, their age, and their past close relationship to Margaret to stay in her house for five days and five nights to mourn and to chant the *endrilangs* ("dirges") for the dead. When Francis Paliau closed his remarks, he and the men stood against the walls. The women sat on the floor sobbing and dirging, as they are accustomed to do in the house of mourning. JK's wife, Siska, who feels herself to have been closest to Margaret, and to me, pulled me down to her where we sobbed together. The dirging and sobbing continued for perhaps twenty minutes or a half hour, until the women's grief, renewed by our arrival, was drained away.

We knew that in Manus, when a person of importance dies, relatives are expected to come home to wail and mourn in the house of death. Relatives often live in distant villages. Nowadays, many work in remote towns on the mainland and may come home weeks or even months later. It was understood that we had come as part of Margaret's family to share this tradition.

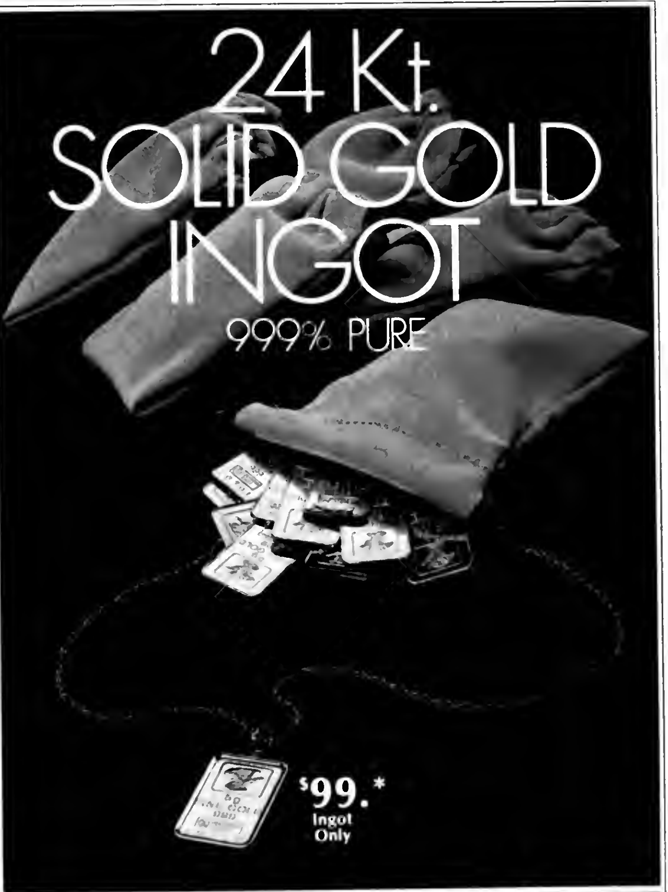
It was appropriate, too, that several days after we arrived, and after Pere's formal mourning was complete, Paliau Maluat came from Baluan Island with a dozen leaders from various Manus and non-Manus villages widely scattered throughout the Admiralty Islands, to express their sorrow and to offer eulogies. Paliau Maluat, the leader of a movement that transformed Admiralty Island culture, had figured prominently in Mead's *New Lives for Old* (1954), as well as in Schwartz's monograph on the Paliau Movement (1962). Paliau Maluat spoke of Mead's belonging to all of them and to the entire world, not just to Pere. He was less

flamboyant in his oratory than usual, moved by the loss of this great friend who had understood and sympathized with his movement and who had helped others to understand and accept him back in the days (1953) when the colonial government considered him only a cultist and a subversive. All were subdued as they claimed their right to mourn. We made our own speeches thanking them, and then, silent in our own meditations, we all quietly left the hall and went to bed.

In two or three days we learned—more deeply than we could have from observation of events in which we were less involved—of the solace that can come from sharing one's grief within a close community of mourners. We thought of Margaret Mead's daughter, Mary Catherine Bateson, and of her friend and companion Rhoda Metraux and wished that they too could have shared this ancient balm of community.

The day after we arrived in Pere, John Kilepak came to the house, limping and carrying his hand-carved cane. We could see that he had begun to recover his normal liveliness, although his thoughts clearly centered on the details of adherence to all the customs befitting the death of an important person. He told us that the five days of mourning and the ceremonies (*sowerai*) held when we arrived were a special honor reserved for a great chief; that there had been only two *sowerai* since 1928—one for Korotan, who had been the aging, nearly blind chief during Margaret's 1928 visit, and the other for Pokanau, the leader who was a principal informant to Mead and to Schwartz. He explained that the official mourners were a self-selected group of those of appropriate prestige who had been particularly close to Margaret; that three of these women had specially composed *endrilangs*, which recounted the history of her visits to Pere and what they knew of her career and renown in the outside world. He reminded us that some sort of present was in order in recognition of the women mourners and those who had provided them with food during their days of mourning.

Recompense for official mourners is a surviving tradition. After some discussion with John Kilepak and Francis Paliau, we arranged to distribute to the women, and to those who had provided for them, 150 sticks of tobacco and three bolts (about 120 yards) of cotton print fabrics. The distribution was



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made on the beach behind our house, in the shade of a magnificent *Calophyllum* tree. Francis Paliau, speaking on behalf of the committee (the town council), explained that the presentation was our acknowledgment of the *sowerai* and the honor paid Margaret Mead. The names of the twenty-six recipients were read and the bolts of cloth laid out and measured to appropriate lengths—in the midst of much noisy, unsolicited advice from the sidelines, some raucous shouting about who were proper recipients, and eventual apparent resolution of disagreements. A few days later, women, husbands, and children began to appear in new laplaps.

When a deputation of village leaders came to our house on the evening before our departure, we did not know what to expect. We invited Francis Paliau, John Kilepak, Petrus Pomat, Karol Sori, and Alex Polin to come in and sit with us around the table, where we had just finished supper. Other men sat around the room on the remaining chairs and stools and on the floor. When Francis Paliau judged that everyone had arrived, he said, "Now we have some talk. Two big men—John and Petrus—are here. They will tell us their talk." It became clear that from the outset John Kilepak had been the behind the scenes force who had suggested how the village was to respond to Margaret's death. He was really the chief mourner, with sensitive concern for the scrupulous observance of traditional ceremonies. He reminded us that on the first day of mourning everyone had stayed inside the houses; that twenty-six women had been the official mourners who slept in Mead's house for five days and nights; that the village had waited for our arrival so that all of us could "cry together." He went on to say that after they had "made the *sowerai*," he, Petrus Pomat, Francis Paliau, the committee, the "big men," the women, the young men, and the young women had held many discussions about what Pere could give to show their love of "Margarit," express their appreciation of her special feeling for Pere, and share in the homage paid to her in America and elsewhere in the world. He said they had come tonight to give us a present for her family, for her friends, for her colleagues in anthropology; that "mining bilong en [its meaning]" was the loss Pere felt, the love and admiration they had for Margaret, and their wish that her work should continue.

Francis Paliau continued with the observation that Papua New Guinea, as well as America and countries all over the world, mourned for Margaret. He said, "We in Pere have thought a great deal about something we can give. It isn't much because we don't have much, but all the same we give it to remember Margarit for all time. We thought plenty and we decided to give this money." He held up strings of Papua New Guinea's dollar-size kinas (worth about $1.40 a piece at present). "These are kina. Fire can't eat them. They can't buggerup. You can look at them plenty year more. Kina don't belong to other countries. They belong to

Peter Goldberg, AMNH

Pere's gift is presented to the Museum by John Kilepak, as Theodore Schwartz and Margaret Mead's granddaughter look on.

A highlight of the 1979 Margaret Mead Film Festival was John Kilepak's presentation of the village of Pere's gift of kinas to the American Museum of Natural History. This was Kilepak's second trip to the United States, and he had spent the summer in California helping to identify photographs, recheck genealogies, and complete a dictionary and grammar of the Manus language. His appearance at the Film Festival followed a screening of the documentary *Margaret Mead's New Guinea Journal*, and the audience, having just seen him in the 1968 film, listened appreciatively as he spoke in pidgin about Margaret Mead and Pere. Kilepak said the people of Pere were glad that Mead had recorded the traditions of their ancestors at a time (1928) when the villagers themselves were unable to read or write. He commented that this earlier generation had passed away, and that now Margaret Mead, too, was one of the ancestors. But, he emphasized, a part of her still lives here and in Pere. Kilepak then presented the string of kinas and explained how, according to custom, such a gift signified the end of mourning. The kinas were accepted on behalf of the Museum by the director, Thomas Nicholson, who gave Kilepak one of the wooden staffs Mead characteristically carried, to take to the people of Papua New Guinea.

New Guinea tasol [alone]. These are a present for Margarit, a mark from us that we always remember Margarit, a mark that you will always know that we remember.''

Karol Sori, who had collected the kinas from each clan, and Alex Polin, a young schoolteacher who had collected them from the Young Men's Association (an organization of the young men of Pere who live and work elsewhere in Papua New Guinea), presented us with the coins, sixty in all. Kinas have holes in the middle, so they can be tied together on strings, as dogs' teeth were strung together for ceremonial exchanges in ''taim *tumbuna*'' (the times of our ancestors). With the strings of kinas we received lists of the donors from each clan and from the Young Men's Association.

How I wish I could summarize Pere's way of mourning Margaret's death as she would have re-created it in her vivid, dramatic style. I can see her with her five-by-seven-inch notebook with the marbled black-and-white hard cover, jotting down observations in her tiny, rapid handwriting, which she herself found difficult to decipher. I can see her checking the tape recorder, making certain that the record was being kept for the archives. And I can see her peering over her rimless glasses to be sure that we were alert with our cameras. She would have commented that the trend toward combining the old with the new, which she noted in 1975, is continuing. She would have observed the ways in which her friends are steadfast, and at the same time, endlessly innovative in their adaptation and manipulation of traditional behavior to fit their conception of today's world. She would have been delighted with the traditional *endrilangs* and particularly by the adaptations of the words to reflect incidents in her life and her special relationship to Pere. In 1975 she wrote that ''the extreme emphasis on modernization and rejection of an earlier period is now gone.'' She would have considered significant the revival of the traditional mourning ceremony honoring her.

The most important of ancient ceremonies celebrated either the joining of families through marriage or the passage of a person from life among the living to life among the ancestors, who remained ever near and concerned with those left behind. For the Manus, Margaret Mead was now an ancestor, together with those who were living in 1928, who had accepted her in Pere.

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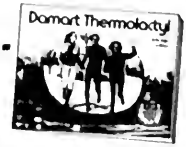

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Asteroid Satellites and Shapes

Some of these small objects may have moons that are even smaller and some may be elongated and shaped like dumbbells

Often called minor planets, asteroids are relatively diminutive rocky objects found mainly in a ring, known as the asteroid belt, between the orbits of Mars and Jupiter. A few follow paths that cross the orbit of the earth, while others—the Trojan asteroids—actually share Jupiter's orbit: one group of Trojans leading the giant planet as it circles the sun, while a second group follows.

Just as Mars and Jupiter have moons, one can imagine that an asteroid might have smaller satellites within its so-called sphere of influence. This imaginary sphere is the region within which a moon will remain in orbit despite the disturbing gravitational pulls of the sun and the major planets. A typical 80-mile diameter asteroid, located not too close to a major planet, has a sphere of influence more than 18,000 miles in diameter.

The evidence for asteroid moons, or minor satellites, as these purported objects are termed, comes from asteroid light curves and from several recent asteroidal occultations. A light curve is a record of the brightness of an asteroid as it turns on its axis. An occultation in this context is the eclipse of a star by an asteroid.

As it passes in front of a star, an asteroid may cast a dim shadow on the earth. An observer in the shadow path sees the star momentarily disappear. Because of uncertain knowledge of asteroid sizes and orbits, the position of the shadow path cannot be predicted with great accuracy. As a result, occultation studies depend on the sightings of many observers, spread out over the likely region. Although most of the observers are amateur astronomers, they have an official coordinating organization, the International Occultation Timing Association (IOTA).

Professional astronomers have occasionally speculated on the existence of minor satellites, but a recent flurry of reports concerning these moons stems from an occultation observed by an amateur on March 5, 1977. At that time, Paul Maley, an amateur astronomer observing from Victoria, Texas, reported seeing a bright star in the constellation Cetus disappear at nearly the same time that the star was occulted by the asteroid Hebe, as seen from Mexico City. Observers north of Mexico City but south of Victoria did not see the star disappear, confirming that Hebe's shadow lay to the south. This was taken to mean that the event seen from Victoria was an occultation of the Cetus star by a small object—presumably a minor satellite—fairly close to, but north of, Hebe.

Although he is an experienced observer, Maley could have been mistaken. The event lasted only half a second and was observed visually, so no instrumental record was preserved for inspection. Even the most seasoned professional astronomers have made errors in visual observations. Nevertheless, some occultation experts, including David W. Dunham, an astronomer at the Computer Sciences Corporation in Silver Spring, Maryland, took Maley's report seriously. In the July 1977 issue of IOTA's *Occultation Newsletter*, he and Maley pointed out that "if there is a satellite of Hebe, it is possible, and probably likely, that there are several others, orbiting other large minor planets as well." IOTA members kept this possibility in mind in planning observations of subsequent occultations.

The Hebe event aroused interest, but it was an occultation by the asteroid Herculina that led to the current lively debate on the possible existence of minor satellites. The occultation of the star SAO 120774 by Herculina on June 7, 1978, was not expected to be seen from the United States. However, measurements of Herculina's position only two days before the occultation revealed that the shadow path would cross the southwestern states, and Dunham quickly alerted potential viewers. Although the asteroid was very low on the horizon and twilight had begun, the occultation was successfully observed from two locations in the Mojave Desert of California and from the Lowell Observatory in Flagstaff, Arizona.

One of the Mojave observers was James H. McMahon, an amateur astronomer from China Lake, California. He stopped his truck "on the west side of U.S. highway 395 approximately 3.54 miles north of Kramer Junction" to consult maps before proceeding south, but the truck would not start again. So he set up a telescope on the spot and began watching the star SAO 120774. Herculina was too dim to be seen, but the asteroid's eclipse of the star—the primary occultation—was duly noted. McMahon also reported six other brief disappearances, or "secondary occultations," of SAO 120774. One, which occurred ninety-seven seconds before the primary occultation and lasted for four seconds, turned out to correspond to a five-second secondary occultation in the photoelectric observations obtained at Lowell Observatory.

Advocates of the existence of minor satellites cite the Herculina observations as confirmation of the presence of a companion to this asteroid. After all, there were two independent observations of a secondary occultation—McMahon's and that at Lowell—and the Lowell observation is preserved as an instrumental record that can be inspected by critics. On the negative side, however, are the five other unconfirmed secondary events reported by McMahon. No one else saw them, not the second Mojave Desert observer nor anyone at Lowell. If these five are spurious, then the sixth McMahon secondary occultation must also

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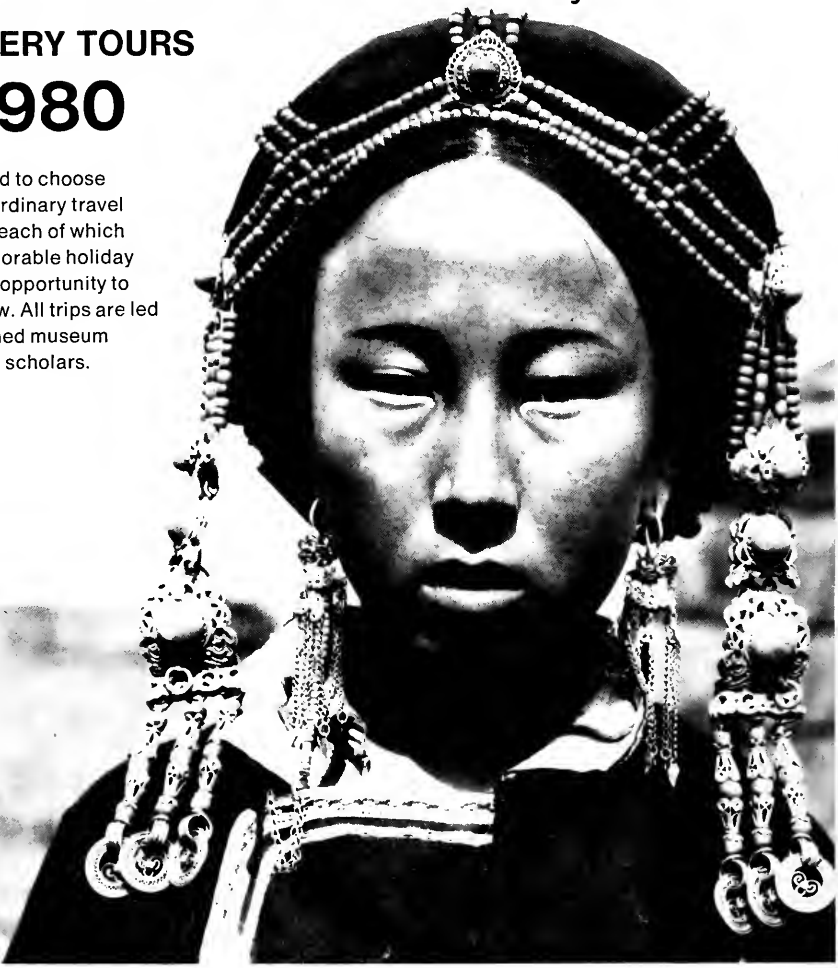

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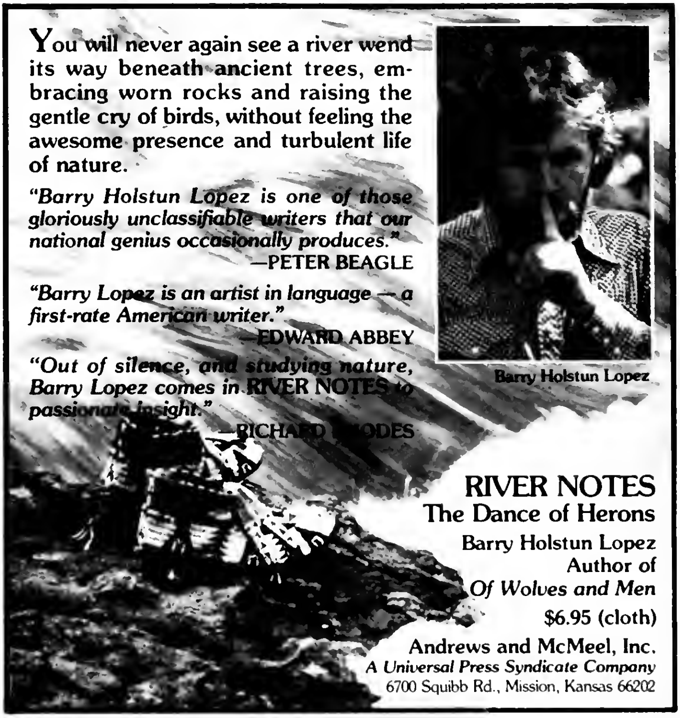
be suspect. (Another possibility, of course, is that Herculina has six minor satellites, one large enough to cast a shadow both near Kramer Junction and in Flagstaff, the other five much smaller and only shadowing the Mojave site.)

What about the Lowell Observatory measurements? By our analysis, the case for a Herculina satellite rests mainly on them. They were made at an altitude of only about three degrees above the horizon, where because of atmospheric interference, astronomers do not normally take photoelectric measurements. However, a record of the primary occultation, published in *Sky and Telescope*, looks excellent and bears out the report that the atmospheric conditions were exceptionally good. The record of the secondary event has been acclaimed by some specialists but looks poor to me.

In the March 2, 1979, issue of *Science*, two strong advocates of the occultation evidence, Richard P. Binzel of Macalester College in Saint Paul, Minnesota, and Thomas C. Van Flandern of the U.S. Naval Observatory in Washington, D.C., summarized observations of eight asteroids. From secondary occultations reported by various observers, the two advocates deduced the possible presence of twenty-three minor satellites, with one (the McMahon-Lowell Herculina satellite) classified as "confirmed," twelve others as "probable," and ten as "suggested." Just two days earlier, however, an experiment at the University of Arizona in Tucson cast some doubt on the whole subject of secondary occultations. In a subsequent issue of *Science*, the Arizona experimenter Harold J. Reitsema told how he monitored a faint star low in the sky as the asteroid Egeria passed by. Three photoelectric telescopes were used, and at least two apparent secondary occultations were recorded with each. But some were due to telescope tracking errors, and none was detected with more than one telescope. Reitsema concluded that many of the prior secondary occultation observations may be spurious, perhaps caused by drifting clouds, passing airplanes, or telescope and instrument problems.

Despite the above comments, the Lowell observers are experts and they were in Flagstaff on June 7, 1978, whereas Reitsema and I were not. We are left in suspense; there is reasonable but hardly compelling evidence that Herculina has a companion. For the



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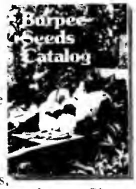

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seven other asteroids discussed by Binzel and Van Flandern, the evidence is weak, but it is at least suggestive.

So much for the occultation observations. The other evidence for minor satellites is in the form of light curves. Astronomers study light curves to determine the rotation, shape, and gross surface properties of asteroids. If an asteroid were perfectly round, smooth, and uniformly reflective, its brightness would remain steady as the object turned. However, asteroids (like astronomers) are generally imperfect, and light curves reveal their deviations. In the March 2, 1979, issue of *Science*, Edward F. Tedesco, an experienced asteroid observer at the University of Arizona, described the light curves of the asteroids Pales and Ophelia. Unlike many other asteroid light curves, those of these two have noticeable V-shaped dips, or "minima." This is reminiscent of the light curves of certain stars, including the famous Demon Star, Algol, in the constellation Perseus. V-shaped minima in stellar light curves are known to result from partial eclipses, as one member of a binary star system passes in front of the other. By analogy, Tedesco proposed that each of the asteroids Pales and Ophelia is a binary asteroid, its satellite revealed by eclipses of the known asteroid. This interpretation seems fair but not definitive, because the published light curves are not long enough to enable the effect to repeat itself over and over. In the near future, further measurements should settle this question. Until then, we have modest but not certain evidence that there are binary asteroids.

What about elongated asteroids? One case is especially significant. The brightness of Hektor varies by a factor of three. If we restrict our consideration to the surface properties of other well-studied asteroids, then a brightness variation this large would be hard to account for. Thus, it would seem unlikely that Hektor is simply an asteroid with a white side and a black side.

A past suggestion was that Hektor is a binary, but a factor of three is rather extreme for the light curve of a binary. To produce such a large light variation, one asteroid in the binary would need to have such extreme properties that we might as well consider a single, highly unusual asteroid as the cause of the light variation without postulating the presence of a companion. Such an asteroid would be a very elongated ob-

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ject, with a length of about 190 miles and a thickness of 95 miles. Such a shape would not be surprising in a small asteroid; minor planets in the asteroid belt are gradually grinding themselves down by repeated collisions and hence must produce some fragments in the form of huge rock splinters. But Hektor, a Trojan asteroid, is by far the largest member of its group and is located where high-speed collisions are unlikely. Hence, it ought not to be a fragment; on the other hand, other large asteroids tend to be round, while Hektor apparently is not.

Last year, two well-known planetary scientists, William K. Hartmann of the Planetary Science Institute in Tucson and Dale P. Cruikshank of the University of Hawaii in Honolulu, proposed that Hektor is not a fragment but rather a "somewhat dumbbell-shaped object . . . resulting from partial coalescence" of two round, earlier asteroids that collided at low speed and hence did not break up. This would account for the elongated shape inferred from Hektor's light curve. On the other hand, this hypothesis is so unusual that the possibility that Hektor is just a round asteroid with a very dark side and a very light side deserved to be reexamined. To test this possibility, the two astronomers made a critical search in April 1979 with an 88-inch telescope on Mauna Kea.

In visible light, an asteroid shines by reflected sunlight. In infrared light, it glows by emission from its own surface, which is heated by the sun. The visible light curve should have maximum brightness when the lighter side is viewed, but the infrared light curve will reach maximum when the *dark* side, being hottest, faces the observer. Thus, the light-and-dark-sides theory predicts that the two light curves will be out of phase. The elongated shape theory, however, predicts maximum brightness in both visible and infrared light when the long side of the asteroid faces the observer. According to this theory, the light curves should be in phase. And, indeed, Hartmann and Cruikshank found that the visible and infrared light curves vary in unison. This proved that their deduction is correct: Hektor is elongated—probably dumbbell in shape.

Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

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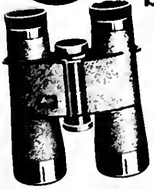

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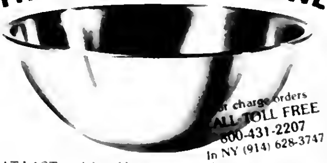

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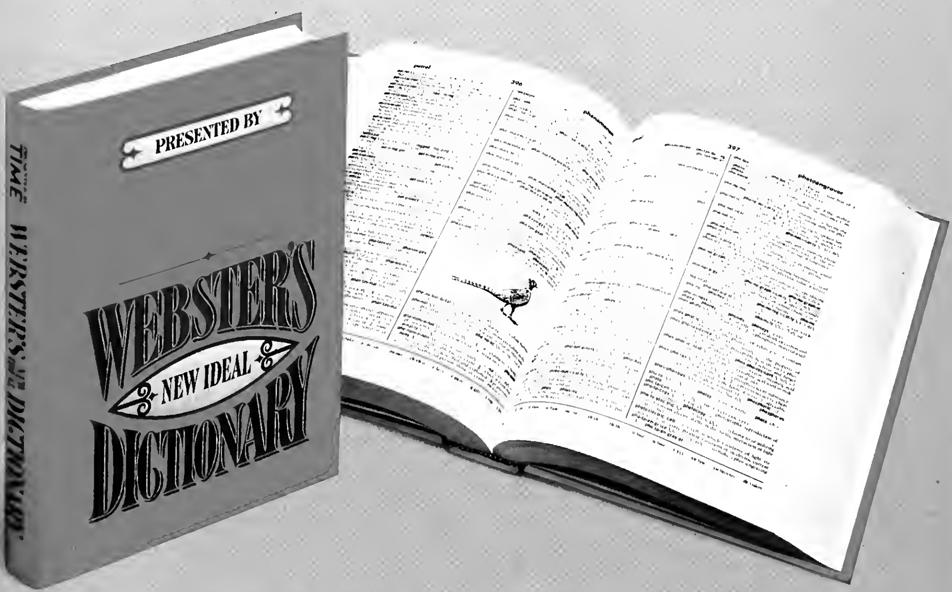

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It's Only a Cod

As fish stocks are depleted, they are exploited all the more avidly

"I believe the cod fisheries are inexhaustible. . . . Nothing we do seriously affects the number of fish."

Thomas Huxley (1825–95)

Back in 1965, within a few minutes of reaching the shoals in the channel between East Bunker's Ledge and Isleford, Maine, everyone on board could be heard shouting, "I've got one!" Cod was the easiest prey. Mimicking local prejudice, we were not totally enthusiastic when twenty pounds of *Gadus morrhua* came swimming and swirling up from below and had to be gaffed on board.

"It's only a cod."

Some of the local families refused to eat cod. Haddock on the other hand always made a fine gift (after I learned that no one wanted a fish that had not been cleaned, no matter what the species). And for a few years, haddock were plentiful, each one making a delectable fish fry for three or four people. By 1970, however, haddock could no longer be had on the nearest shoals.

"They've gone offshore," the men at the dock said, implying that some temporary shift in current, change in water temperature, or cyclical variation in feed had taken place. If you knew the proper spots, farther out on Edge of Bottom, Lervy Grounds, John's Rock, or the Meeting House Grounds, you could still catch all the haddock you wanted. Unless you were incompetent.

Going out to the more distant shoals helped for a while—especially after I began to find my way to the Columbian Ledge near Mount Desert Rock, twenty miles at sea. But by 1972 even the party boat captains were admitting that there were no haddock to be caught no matter how many shoals you went to, whether you had a Fathometer on board or not, whether you baited with squid or shrimp or clams, used diamond jigs, big hooks, little hooks . . . it was all the same.

"It's the factory ships offshore," Tud Bunker explained. "Russians, Poles, Germans—everybody. They do the freezing and packing right on board. A mother ship, maybe 500 feet long, and a lot of smaller ones. But even the smaller ones are bigger than any of the boats around here."

Most marine biologists and fishery experts agree. Haddock and cod found in local waters probably migrate annually from the sole remaining great New England fishery, Georges Bank, offshore in the southern fringes of the Gulf of Maine. As a result of overfishing by foreign fleets, especially Russian ships, the amount of haddock taken on Georges Bank collapsed from a record high of 155,000 tons in 1965 to a record low of 28,000 tons in 1968. This disaster prompted much of the support for the 200-mile territorial limit and quotas on foreign and domestic haddock landings now in effect on Georges Bank. But these measures may have come too late. Right now the only fresh haddock for sale at the local fish wharf is from Iceland. As I recall how recently my landlubber crew was catching haddock on the nearest shoals, I am awed at the destructive power of those unseen fleets operating far over the horizon.

Yet the foreign devil theory does not tell the whole story. Since the introduction of motorized net fishing early in the century, small boats have had the capacity to overfish the local waters. Dragged day after day with otter trawls, shoals turn into underwater deserts. The heavy wooden wings, or doors, that keep these nets open and the iron bars that protect the leading edge of the opening scour the ocean floor, destroying the communities of plants and animals that make the shoals inviting to such bottom-dwelling species as haddock and cod. Gill nets, used when the bottom is too rocky to be dragged, are also destructive. They are suspended from a line of floats near the bottom. The fish put their heads into the mesh and then can't back out. In rough weather these nets sometimes break loose from their surface moorings and hang there, silently catching fish year after year. Both kinds of nets are more of a threat to fish stocks than the old hook-and-line tub trawls that were the mainstay of the traditional inshore New England fisheries. Unlike baited hooks, nets catch undersized and unmarketable fish, which must be thrown away.

My neighbors refuse to implicate the local draggers and gill netters in the sudden dearth of haddock. "You don't want to tell a man that he can't make a living," they say. Nonetheless, the only thing that has ever protected the local fishing grounds from destruction by small gill netters and draggers has been the low price offered for cod and haddock at the nearby fish wharves. As long as the big fleets were catching thirty or forty tons of fish per day per ship on Georges Bank, the relatively inefficient local boats could not make a living on the inshore shoals. But when the Georges Bank haddock fishery collapsed in 1968, prices rose sufficiently to make it worthwhile to drag and gill net the shoals between Mount Desert Rock and the shore. With the annual migrations from offshore down to a trickle, the local fishermen, goaded on by rising prices, fished and fished until

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hardly a haddock was left in the area.

The cod may be next. As usual, my seafaring friends at first denied that anything was wrong. "You can always get cod on the Lervy Grounds," Junior insisted. "You got to get on the edge of it. Let the back side of Cranberry come out a boat length past Baker's."

"You ought to try the Eastern Muddy Reef," said Karl.

"Pshh! You don't hold your mouth right," quipped Lynn.

My own doubts lingered until Tud Bunker took some time off to go to the "Rock" with me. After several hours of sawing our handlines back and forth, Tud said, "Let's go home. There are more fish in my well than there are out here." On the way in he tried the spots he had known as a young man, when he had set trawls and handlined for a living. "You used to be able to come here and pull in two or three hundred pounds of cod on the slack tide, all good market size, and come back the next day and do the same thing. I've never seen it like this."

Now that it can no longer be denied that something is wrong, everyone has a different theory to explain what is happening.

"The feed isn't in yet."

"The whales haven't come down the coast. They'll be pushing the fish ahead of them."

"Too many whales around. They're scaring off the fish."

"Water's too cold."

"Water's too warm."

At first, no one mentions the draggers and gill netters who were busy catching cod all last year, the skyrocketing price of fish at the supermarket, and the record prices for cod at the local fish wharf. The most plausible theory is that cod are about to go the way of haddock, which was the way of hake before haddock, and of salmon before hake.

Most alarming is the sudden rise in the cod's Nielsen rating. Summer people who once turned up their noses at "smelly old codfish" now want to know why they have been overlooked. And suddenly there are more people than ever fishing for cod—more boats with better equipment; more Fathometers, sonar, radar; more people fishing cod for sport, for part-time subsistence, or just for an evening's meal.

This, then, is the perverse logic of depletion: the more vulnerable a species or a resource becomes, the more avidly it is exploited. The process I have been describing in miniature is writ large on Georges Bank, and still larger all around

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the globe. As Lester Brown has shown in a recent *Worldwatch Paper*, an ever greater effort is needed to maintain the present rate of oceanic fish production. While annual fish harvests more than tripled between 1950 and 1969, there has been no increase at all since then. And yet the size of the world fishing fleet increased by 50 percent between 1970 and 1975. This has meant a precipitous drop in return per dollar invested—diminishing returns, which consumers experience as rising prices. Behind it all lies the relentless depletion of the most accessible fishing grounds.

It is a wonder that the cod fisheries have held out so long. What saved them until a few years ago was the preference for haddock. Actually, during the nineteenth century, when fish were preserved for the market by being salted, the relative standing of these two species was different from what it is today: cod was preferred over haddock. Cod salted well, remaining firm when soaked overnight to remove the salt before cooking. But haddock, with its more tender flesh, became mushy and had the reputation of being a trash food fit only for slaves. The introduction of onboard icing techniques raised the demand for haddock. Cod production peaked in 1880 at 147,000 tons—a figure that probably will never be reached again in spite of all the technological advantages enjoyed by today's fleets. Throughout the first part of this century, therefore, haddock acted as a buffer against further depletion of cod stocks. But with haddock out of the way, the full cunning of our technological genius is now directed against the cod. In the strange new world we are building, fresh cod may soon be as expensive as caviar.

Of course, with the 200-mile limit and the international quotas, one need not be so pessimistic. With careful regulation, perhaps cod and haddock yields on Georges Bank and the other great offshore fisheries can be maintained. We are told that under scientific management our forests are being regenerated faster than they are being cut down. But they are not the same forests: miles of regimented 35-year-old sticks have replaced towering giants that took hundreds of years to grow.

My neighbors all think that the cod will come back, but I doubt that it will ever be the same—that anyone will catch a twenty-pounder in the channel between Isleford and East Bunker's Ledge again.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon November is the only month of the year in which the sun appears in three separate constellations. It starts in Libra, moves into Scorpius about the 23rd, and into Ophiuchus on the 29th. Although the shortest day of the year is not until late December, the sun will be so far south of the equatorial plane by the end of November that sunset then will be only one minute later than its earliest, and daylight will last only 15 minutes longer than its shortest duration of the year.

November's full moon on the 4th is the hunter's moon. Last-quarter occurs on the 11th, new moon on the 19th, and first-quarter on the 26th. In December, full moon is on the 3rd, and the other phases occur on the same dates as in November. The moon occults two bright stars (Aldebaran and Regulus) and two bright planets (Jupiter and Saturn) in both November and December, but only the occultations of Aldebaran on November 6 and December 30 will be visible in North America.

Stars and Planets There are no planets on the evening Star Map, although Venus will begin to appear as an evening star, low in the southwest after sunset, by late November. Mars, Jupiter, and Saturn are prominent morning stars, Mars and Jupiter rising about midnight, Saturn about an hour later. Just before dawn early in November, those three planets and Regulus (the bright star in Leo) will be stretched out in line from the southeast to the south. Saturn is lowest to the left, Jupiter higher and the brightest, then Regulus and Mars to the right. Jupiter and Mars are in Leo, Saturn in Virgo.

November 4: The weak Taurid meteor shower (15 per hour) will be obscured by the hunter's moon.

November 5–6: The bright star near the moon, Aldebaran in Taurus, will be covered by the moon for an hour shortly after midnight, EST.

November 8: Mercury is in conjunction with Venus, but both are too low in the western sky at sunset to be seen.

November 9: Mercury begins its retrograde (westerly) motion.

November 12–15: The waning moon is in the eastern sky each morning, close to Mars on the 12th, near Jupiter on the 13th, near Saturn on the 14th, to the left and below all three planets on the 15th.

November 17–18: The Leonid meteor shower can be seen during the after-midnight hours of Saturday and Sunday morning. Although not very productive in most years (15 shower meteors per hour), the objects are often swift and very bright. Mars passes Regulus on the 17th. The planet has been approaching the star from the west. On the 18th and after, it will be to the star's right (east).

November 19: Mercury, at inferior conjunction, enters the morning sky.

November 21: The crescent moon may help you find Venus, low in the western sky tonight.

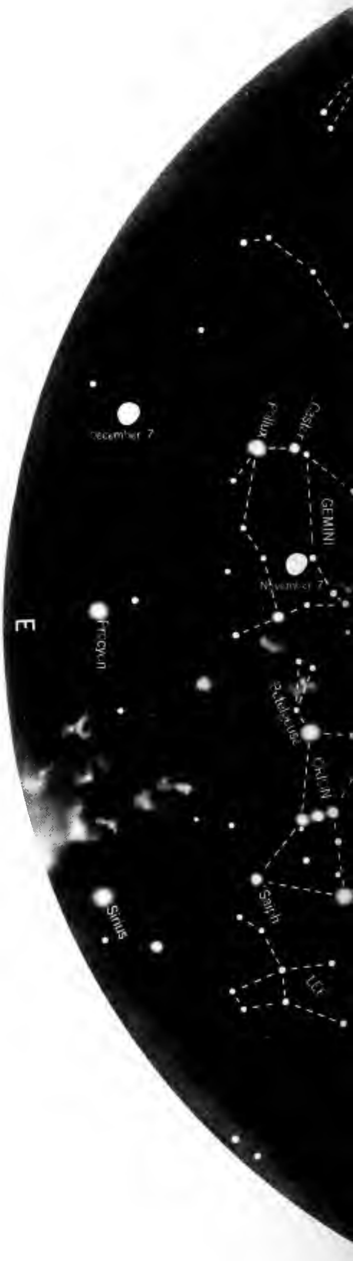
November 29: Mercury resumes direct (easterly) motion.

December 7: Mercury is at greatest distance to the sun's right. The planet is in good position to be seen as a morning star, low in the east at dawn for a week before and two weeks after this date.

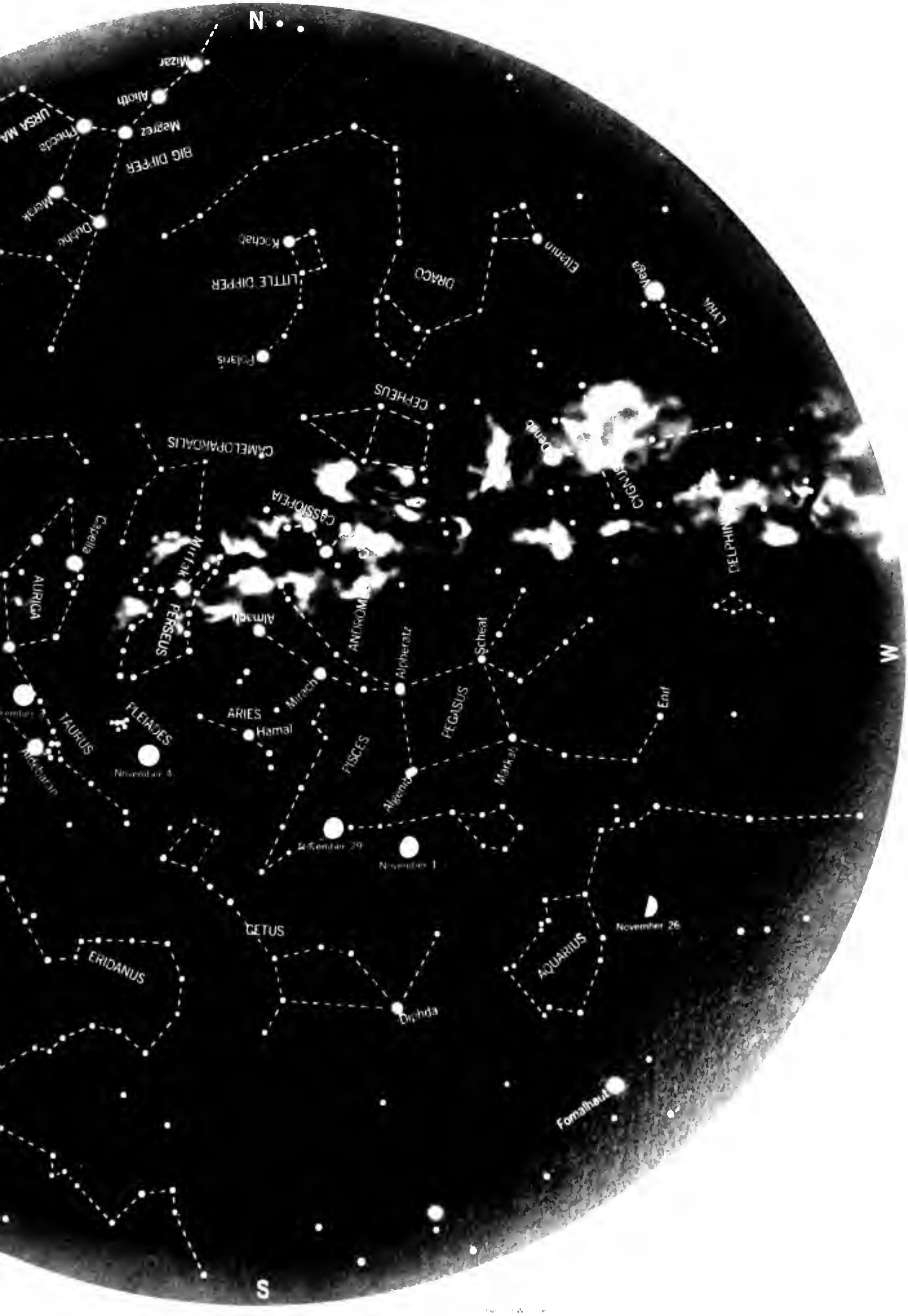
December 9: The moon is near Regulus this morning.

December 10: The moon is near Mars and Jupiter this morning.

December 13: The moon is near Saturn this morning, after occulting it earlier (not visible in North America). Mars, approaching Jupiter from the west, today passes the brighter planet and moves off to the east.



★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:15 P.M. on November 1; 10:20 P.M. on November 15; 9:20 P.M. on November 30; and 8:20 P.M. on December 15; but it can also be used for an hour before and after those times.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Snow Belt of the Great Lakes

The blizzards tend to hit a ten- to thirty-mile-wide area downwind of the lakes

by Gloria Ellenton

In the area surrounding the Great Lakes, the word *winter* often translates as *snow*, which means trouble for motorists but joy for skiers. Indeed these disparate attitudes to winter's bounty may reside simultaneously within the same person. Just how much snow accumulates in the course of a winter can serve to heighten one's feelings of either pleasure or antipathy toward the season.

Around the borders of the Great Lakes, annual snowfall shows surprising variations over short distances. Each lake has a distinct snow belt hugging its eastern or southern shore where the yearly snow accumulation noticeably exceeds that of neighboring

B.A. King

locations. What accounts for some places being more favored or, depending on your point of view, more cursed by heavy winter snows? The answer lies in the complex interactions of air masses, storm tracks, and the earth's topography.

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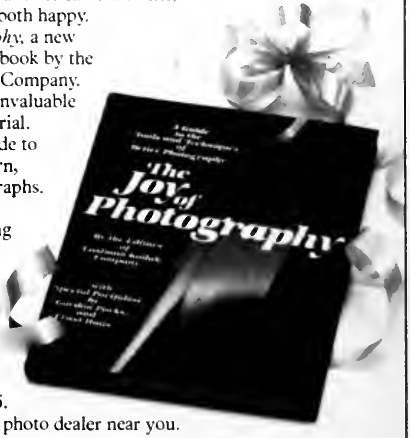

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called lake-effect snow, which falls over certain localities in addition to the widespread precipitation accompanying low-pressure centers that pass regularly through the area. Lake-effect snow—localized precipitation caused by the lakes themselves—occurs when cold winter winds traveling over the open water pick up heat and moisture from the lakes, then drop the moisture in the form of snow over downwind areas.

In at least one aspect, winter weather to the lee of the lakes shows a marked contrast to that at most other locations east of the Rocky Mountains. In other regions, after a low-pressure storm center has passed through, the cold air arriving in its wake brings clearing skies and bright sunshine. Along the lee shores of the lakes, however, the fresh cold winds often cause the formation of dense clouds that produce persistent snow flurries. Sometimes an intense lake-effect blizzard develops. Swirling, blowing snow reduces visibility to zero. Transportation comes to a halt as the steadily falling snow, accumulating faster than snowplows can clear it away, is blown into deep drifts

Buffalo Evening News photograph by Robert E. Stoddard

along the highways. A whole community can be paralyzed and isolated from its neighbors. Curiously, this type of "snow dump" from a lake storm is often concentrated over a narrow, corridorlike area of heavy snowfall about ten to thirty miles wide and reaching inland some fifty to one hundred miles. Outside of this corridor there may merely be a light dusting of snow.

Fortunately lake-effect snowfall is only occasionally this severe. It usually takes the form of more moderate flurries spread over a broader but still limited area. Lake snows of either type characteristically continue over the same locations for many hours, sometimes persisting for as long as one or two days.

Similar conditions are found along the west coast of Japan. When cold air from Siberia crosses the relatively warmer waters of the Sea of Japan, snow clouds develop and move inland, producing sea-effect snowfall in the western coastal region.

The Great Lakes contain such large volumes of water that they have a great capacity for heat storage. This means that in autumn they cool much more

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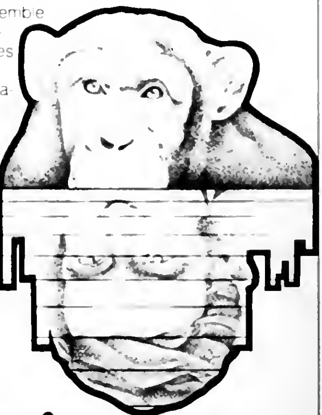

The Ape's Reflexion

Adrian J. Desmond

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slowly than the land around them. During the winter a considerable area of the lakes' surface remains as open water. The size of the ice-free area, however, varies from lake to lake and from one winter to another. Lake Ontario remains open over most of its surface even during the most severe winters. Lake Erie, the shallowest of the lakes, gradually freezes over during normal winters, becoming entirely ice covered by about mid-February. The extent of the open-water area in the other lakes varies between these two extremes. These open-water surfaces provide a vast reservoir of moisture and heat, which can be transferred to the air flowing over them.

Heat from the Great Lakes is sufficient to affect the pattern of surface air pressure in the lakes' region. After a low-pressure center has moved through the region and passed off to the east, pressures would normally be expected to rise. Instead, the warmth of the lakes' surface relative to the cold surrounding landscape creates a tendency toward lower pressures during the ensuing onslaught of cold air. As a result, a trough of low pressure lingers over the area for an extra day or two. Since low pressures provide a favorable environment for cloud formation, this is one contributing factor to lake-effect snowfall.

Moisture and heat from the lakes also create the actual mechanisms of cumulus cloud formation. When the lowest levels of cold air are heated by contact with the warmer water surface, bubbles or plumes of buoyant air break away from the surface and start to rise through the atmosphere. These rising parcels, or columns, of air carry moisture evaporated from the lakes' surface. The air cools as it rises and its ability to hold water vapor decreases accordingly. At some point during its ascent, the air will reach a temperature at which it is saturated, that is, it will hold its limit of water vapor. As this saturated air continues to rise farther and cool still more, small liquid water droplets begin to condense out. This is the beginning of cumulus cloud formation and the subsequent precipitation of rain or snow.

The moist air will continue its upward climb, continuously cooling and condensing, until it reaches the same temperature, and thus the same density, as the surrounding atmosphere at that level. This determines the height of the cloud tops.

Cumulus clouds in lake-effect

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storms are typically shallow, with tops usually below 10,000 feet. This is well below the cruising level of large jet aircraft, which normally fly at 15,000 to 40,000 feet. Despite their shallow nature, these clouds are very active, creating an abundance of snowfall.

We have seen how the lifting of moist air creates cumulus clouds and precipitation. A further lifting may take place when moist air encounters certain land features while flowing inland after traversing one of the lakes. As it crosses the shoreline, the moist air passes from the relatively smooth and unresistant water surface to the uneven land surface dotted with rocks, trees, and buildings. These obstacles increase resistance to the air flow and give the air a tendency to rise. When the air approaches hills it is forced to lift over them and drop its precipitation on their windward sides. In lake-effect snowfall situations, this side is on the westerly or northerly facing slopes. The orientation and shape of the shoreline and of the rising topography, in combination with wind direction, are what influence the pattern of snow accumulation.

Heat energy from the lakes provides the fuel for the cloud-building activity. The amount of heat transferred from the water to the air is proportional to the difference in temperature between the air and water at their interface. Strong winds tend to increase this transfer of heat across the air–water boundary. If the difference in temperature between the water surface and the air is greater than 20°F and the wind speed is fifteen to twenty miles per hour or more, lake-effect snowfall is likely to occur.

What then are typical conditions during the winter months? In January and February, lake surface temperatures are fairly uniform, averaging slightly above freezing over the open water surface. The temperature of the air close to the surface varies considerably as warm and cold air masses follow one another across the Great Lakes region.

The cold air masses are of two general types, depending on their origin. Cold air that originates over the north Pacific Ocean and crosses the continent has typical surface temperatures somewhere near 10°F. The very coldest outbreaks of air reaching the Great Lakes from the Arctic can have surface temperatures as low as −40°. Under such extreme conditions, the air–water temperature difference can be as great as

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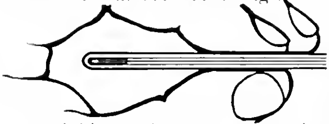

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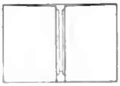

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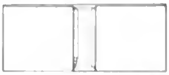

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70°. This extreme value is modified as the air warms up during its passage across the lakes. Nevertheless, the temperature difference between the air and water in contact is still large, with the result that a great deal of heat continues to be added to the air and is carried upward.

The lake surface also supplies heat energy in the form of latent heat of vaporization. When water from the lake surface evaporates into the air, heat from the lake is absorbed in the process of converting the water into water vapor. This heat is then released into the atmosphere at some higher level when the water vapor condenses into cloud water droplets. The lakes thereby supply heat energy to the atmosphere in two forms, "sensible," or direct, heat, and latent heat of vaporization. Vigorous local snowstorms result from the sometimes very large amount of energy supplied by the lakes to the air in those ways.

Satellite pictures and radar show that lake-effect snow clouds occur in bands resembling streamers that form over the lakes and are swept inland by the winds. When numerous small cloud bands occur they cause widespread snow flurries over the general snow belt area downwind from a lake. These small multiple bands appear to develop when the wind blows across the shorter dimension of a lake. Cold winds blowing from north to south across Lake Erie thus bring snow flurries to a relatively broad area south of the lake.

If, instead, the wind blows along the length of the lake, a single large cloud band will probably form. This intense type of cloud band causes highly localized blizzards. Buffalo, New York, bears the brunt of this when the wind is westerly and traverses the full length of Lake Erie. Watertown, New York, similarly suffers under heavy snowfall when the wind flows from end to end along Lake Ontario. London, in Ontario, Canada, has on different occasions been pummeled by heavy continuous snowfall when northwest winds carried cold air down the long axis of Lake Huron. Lake-effect snow cloud bands are remarkably persistent. They have been observed to cause continuous snowfall over a particular limited area for as long as forty hours.

Banded cloud formations are not confined to the Great Lakes area. Satellite pictures show that cloud bands appear all over the world. Usually, however, they are not as active as lake-effect storm cloud bands. Wherever they

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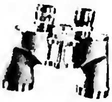
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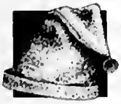
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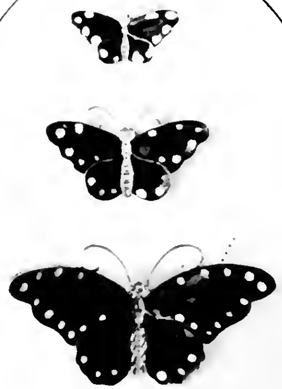
occur, they seem to result from strong winds blowing across a surface heat source. Bands of rising air can also occur without clouds. These "streets" of ascending clear air have been a familiar phenomenon to glider pilots for many years. Even sea gulls take advantage of these invisible row-type thermals for straight-line soaring.

Improved weather observations and the three-dimensional view afforded by aircraft, radar, and satellite observations have made lake-effect snowfall less of a mystery than it once was. With a better understanding of the causes of this type of snowfall, much of the element of surprise is being eliminated. People living in the snow belt areas receive warning of snow flurries to the lee of the lakes in time to plan their activity accordingly, be it shoveling, skiing, or perhaps just waiting out the storm. However, pinpointing the exact location of heavy snow accumulations is still an elusive goal. Answers to the questions of precisely where, when, and how much will fall are still problems to be tackled in the continuing search for better weather prediction.

A resident of the snow belt in southern Ontario, Gloria Ellenton has firsthand knowledge of the phenomenon she discusses. Recent research on lake-effect snow storms done at the University of Waterloo, Ontario, formed part of her doctoral thesis.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The Plight of the Bumblebee

Bumblebee Economics, by Bernd Heinrich. *Harvard University Press, $17.50; 159 pp., illus.*

There is something intrinsically appealing about bumblebees. Fuzzy, brightly banded, and devoted to the fertilization of flowers, they seem the epitome of nature at its most beautiful and efficient. The very name bumblebee (as well as its Latin equivalent, *Bombus*) seems eminently fitting for these bumbling bombs of energy (and, if molested, of venom). They are things of which poems are spun. In *A Midsummer Night's Dream*, Titania, enamored of Bottom, bids the fairies

> Be kind and courteous to
> this gentleman;
> Hop in his walks, and
> gambol in his eyes;
> Feed him with apricocks
> and dewberries,
> With purple grapes, green
> figs, and mulberries;
> The honey-bags steal from
> the humble-bees,
> And for night tapers crop
> their waxen thighs,
> And light them at the fiery
> glow-worm's eyes . . .

Bumblebees have even been given credit for the prestige of the British Empire (have they been shirking their duty lately?). In the *Origin of Species*, Charles Darwin remarked that bumblebees are largely responsible for the pollination of red clover. But their nests are often destroyed by field mice, and since cats destroy mice, bumblebees tend to be most numerous near villages. Darwin's "bulldog," Thomas Henry Huxley, facetiously suggested that since spinsters keep cats, it follows that the more spinsters, the more red clover. Meanwhile, Darwin's German supporter Ernst Haeckel quipped that British power depended upon bumblebees because they pollinated the clover on which cattle fed, and the Navy subsisted largely on beef!

For whatever reason, bumblebees have always been popular with the English, who have written most of the books about them. F.W.L. Sladen's 1912 book has been updated by Free and Butler's *Bumblebees* (1959) and more recently by D.V. Alford's 1975 book, also entitled *Bumblebees.* While all of these deal primarily with British species, they contain a great deal of information that applies to American species as well. The only book on American bumblebees (prior to Heinrich's) is Otto Plath's *Bumblebees and Their Ways*, published in 1934 and now quite scarce.

Bernd Heinrich is a young biologist at the University of California, Berkeley. His first paper on bumblebees was published in 1972. With an energy perhaps inspired by his favorite animals, he has produced a book that is largely a review of his own research and that of several other currently active researchers. It is not a book on the life histories of bumblebees, but on their economics. Economics, you ask? Why not? According to my dictionary, the word is derived from the Greek *oikonomikos*, meaning "skilled in the management of a household" (which bum-

by Howard E. Evans

blebees certainly are). Heinrich defines economics as "the study of the acquisition or production, distribution, and consumption of goods and services" and points out that the concept is usually employed with respect to man, where it becomes involved with politics and technology. Insects are said to have neither, yet social insects such as bumblebees have mechanisms for the allocation of resources within the nest, and the nest itself is a construct of their own making. Thus, in a sense, they do possess both a political system (rather communistic) and a technology. Their economics is one of frugality. "Bumblebees [he says] are very often in an energy crisis of far greater magnitude than anything humans ordinarily experience." Although their fuel, the nectar of flowers, is often abundant, the exigencies of their lives are such that they cannot, in fact, afford to "bumble"; they must proceed with machinelike efficiency.

Bumblebees occur throughout much of the world. They are much more

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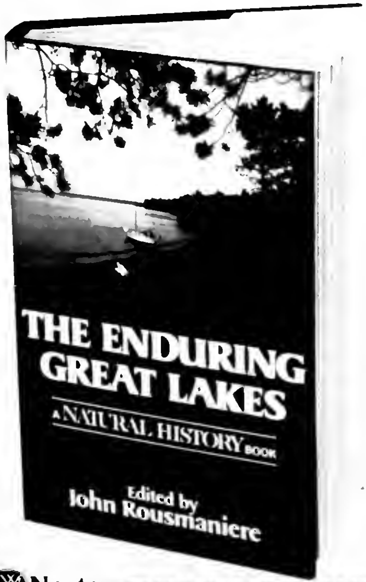

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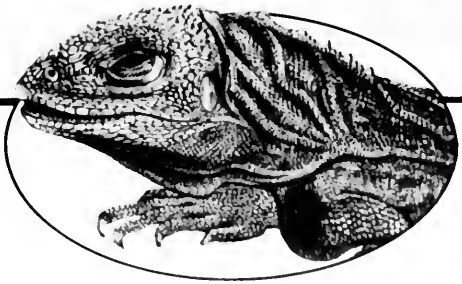

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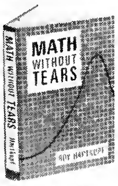

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prevalent in cooler regions than in the tropics, and more than most insects, they flourish on mountaintops and far into the Arctic. Colonies are annual affairs and in the Far North may not last more than a couple of months (fertilized young queens overwinter to start new colonies the next year). Not surprisingly, colonies rarely reach more than a few hundred workers, and some colonies do not make it to the point of producing reproductive individuals. Little wonder that bumblebees always seem to be in a hurry!

If, like most insects, they had to wait for warm, sunny days, bumblebees could scarcely "make a go of it." They often fly in poor weather, even in rain or snow, and have occasionally been seen flying in below-freezing temperatures. Yet they cannot fly unless the temperature of their flight muscles is above 85°F and below 110°F. Bumblebees are not only able to maintain such a flight temperature, but a resting bee, whose temperature is close to that of the air, is able to acquire the necessary flight temperature and take flight within a short time. This is done by "shivering," that is, by rapid contractions of the flight muscles. These are temporarily dissociated from the wings, so that the wings do not move, and the only external indication of warm-up is abdomen pumping, which serves to increase the flow of oxygen into the thorax.

During flight, heat loss is prevented, in part, by the dense hairs on the body and, in part, by an unusual arrangement of air sacs and blood passageways at the base of the abdomen. These serve as what Heinrich calls a "countercurrent heat exchanger," that is, the warmed blood is largely retained in the thorax or, if there is a threat of overheating, is circulated freely to the abdomen, which acts as a "radiator."

The heat exchanger also serves a valuable function in the nest. Bumblebees incubate their brood, thereby protecting it from cold and increasing its rate of development. A queen or worker bee wraps herself over a mass of eggs or larvae, using the thinly haired underside of her abdomen in much the same manner as a bird uses its brood patch. By sipping honey from a nearby honeypot, she fuels her quivering flight muscles, passing the heat into the abdomen and thence to the brood. In this way the temperature of the brood may be maintained by as much as forty-five degrees above the air temperature. But when the bee is removed, the temperature drops to that of the environment. Nest temperature is also maintained by heat from the bees' metabolism, and overheating is prevented by fanning and evaporative cooling at the nest entrance.

All of the fuel and, of course, the nectar and pollen fed to the larvae is gathered during foraging flights. There is no recruitment system as in honeybees; individual workers forage on their own, sampling a variety of flowers until they find kinds that are rich in nectar. Heinrich speaks of bees developing "majors" and "minors," that is, becoming specialists on one type of flower, perhaps a complex one such as monkshood, but retaining the ability to exploit certain other species effectively. "The bees play a game analogous to the stock market. They do not know beforehand which is the most upcoming commodity (flower), and their best strategy is to invest primarily in the flower that appears to be most remunerative while simultaneously investing some energy in several minor species."

Continuing his analogy with human economics, Heinrich points out that the scattered, individual foraging patterns of bumblebees are best suited for the scattered nectar sources they exploit. On the other hand, the elaborate communication and storage systems of honeybees appear to have evolved to better exploit the massive, but often irregular, honey flows that occur in the tropics. "A honeybee colony resembles a big corporation that goes after the big market. . . . In contrast, a bumblebee colony has a more individualistic cottage-industry approach."

Several chapters are devoted to the costs and benefits of various foraging strategies, the avoidance of competition with other kinds of bees, and the like. Bees attempt to reap the maximum rewards from flowers, while flowers have evolved to supply the least amount of food needed to attract pollinators, thus forcing bees to move from one flower to another and to effect cross-pollination. Some flowers signal to bees when they have already been pollinated by changing color, odor, or form. Others cheat, attracting bees by their resemblance to other flowers but offering no reward. And some copy the form and odor of a female bee or wasp, attracting males that attempt to copulate with the flowers and in the process cross-pollinate them.

It is not possible to review all of the topics covered in this book. Persons

accustomed to thinking of bees as "coldblooded" and committed to dawdling away their lives in the meadow will be in for many surprises. The author is not satisfied with generalities, but consistently provides an abundance of facts and figures derived from careful measurements and various forms of "electronic eavesdropping." Yet none of this intrudes upon a style that is invariably lively and lucid, at a level appropriate to persons interested in natural history but not necessarily trained in entomology or biophysics.

I rather wish he had included a chapter on male behavior, even though that is outside the scope of his own research. Males have an economics of their own: the resource they seek is (what else?) females. Males of some species hover in selected places, dashing after passing insects and seizing virgin queens that pass their station. Males of other species establish flight paths containing a series of "visiting points," which are scent marked with a pheromone that is attractive to other males and to females. A good deal remains to be learned about mating behavior, indeed, about many aspects of bumblebee social behavior.

Heinrich provides two appendices. The first is entitled "How to Rear Bumblebees," not a simple matter, but one that can be accomplished with perseverance. Who would want to keep bumblebees? Researchers, of course, and growers of red clover and other plants with deep corollas. And simply as pets, bumblebees are a good deal more interesting than goldfish (and I think, than cats); besides, they more than pay for their keep. Heinrich's second appendix, illustrated with two color plates, is an aid to the identification of the fifty species and subspecies of bumblebees occurring in North America.

The bumblebee that emerges from these pages is very different from Emerson's: "Wiser far than human seer,/Yellow-breeched philosopher!" If not a philosopher, the bumblebee is a product of evolution we can greatly admire. It is not true that science strips away the beauty of nature; it illumines it and deepens its impact. To read this book is to enrich a summer's day and a winter's dreaming.

Howard E. Evans is professor of entomology at Colorado State University and the author of Life on a Little-Known Planet *and* Wasp Farm.

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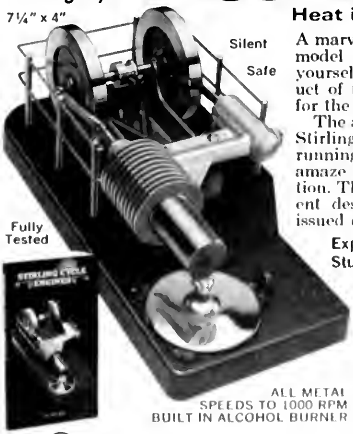

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Additional Reading

Gold (p. 36)

Artifacts of ancient Colombian goldmaking are described in *Gold of El Dorado: The Heritage of Colombia*, by Warwick Bray (New York: Harry N. Abrams, 1979), illustrated with full-size color and black-and-white photographs taken by Lee Boltin. A 546-page *Bulletin of the American Museum of Natural History* (1948) is devoted entirely to "Stingless Bees (Meliponidae) of the Western Hemisphere," by Herbert F. Schwartz. Another paper, "Pre-Hispanic Metallurgy and Metalworking in the New World," by Dudley T. Easby, Jr., appears in *Proceedings of the American Philosophical Society* (April 1965, pp. 89–98). In "Sahagún Reviviscit in the Gold Collection of the University Museum" (*University Museum Bulletin*, September 1956, pp. 2–15), Easby discusses the hollow gold castings done by aboriginal Quimbaya goldsmiths. For a study of another people's metalworking, see "Lake Superior Copper and the Indians: Miscellaneous Studies of Great Lake Prehistory," edited by James B. Griffin (*Anthropological Papers*, Museum of Anthropology, University of Michigan, no. 17, 1961). Still available, "Inca Treasure as Depicted by Spanish Historians," by S. K. Lothrop, a chapter in *Publications of the Frederick Webb Hodge Anniversary Publications Fund, Volume II* (Los Angeles: The Southwest Museum, 1938), is an excellent account of the gold and silver the Spaniards found in Peru. A well-illustrated, popular book about pre-Columbian gold and silver art is *Sweat of the Sun and Tears of the Moon*, by André Emmerich (Seattle: University of Washington Press, 1965).

Butterflies (p. 56)

Effects of the environment on *Colias* wings are discussed in W. B. Watt's "Adaptive Significance of Pigment Polymorphisms in *Colias* Butterflies: Part I, Variation of Melanin Pigment in Relation to Thermoregulation" (*Evolution*, vol. 22, no. 3, pp. 437–58). P. G. Kevan and J. D. Shorthouse discuss how butterflies bask in "Behavioural Thermoregulation by High Arctic Butterflies" (*Arctic*, December 1970, pp. 268–79). "The Role of Butterfly Wings in Regulation of Body Temperature," by Lutz Thilo Wasserthal (*Journal of Insect Physiology*, vol. 21, 1975, pp. 1921–30), treats the adaptive significance of wing pattern with respect to different modes of heat transport. "Role of the Wings in the Absorption of Radiant Energy by a Butterfly," by A. E. Kammer and J. Bracchi (*Journal of Comparative Biochemistry and Physiology*, vol. 45A, 1973, pp. 1057–63), is a study of the physiological mechanism of heat transfer and the rate at which blood flows between the wings and thorax.

African Music (p. 68)

The Music of Africa, by J. H. Kwabena Nketia (New York: W. W. Norton Co., 1974), gives some of the historical, social, and cultural background of African music and discusses instruments, group structures, and related arts. F. Debey's *African Music: A People's Art*, translated by J. Bennet (New York: Lawrence Hill, 1975), is an introduction to the subject with pictures. Although addressed to the musician, the two-volume *Studies in African Music*, by A. M. Jones (London: Oxford University Press, 1959), is also of interest to the general reader. Children's songs and different methods of drumming are covered in the first volume; the second contains full scores of African music. Songs of the Tiv people of Nigeria, composers, style, and musical culture are the subjects of *Tiv Song*, by Charles Keil (Chicago: University of Chicago Press, 1979). A specific dance is analyzed in *Dance and Society in Eastern Africa 1890–1970: The Beni Ngoma*, by T. O. Ranger (Berkeley: University of California Press, 1974). Nketia discusses the social implications of Akan drumming and drum texts, language, and history in *Drumming in Akan Communities of Ghana* (New York: Thomas Nelson and Sons, 1963). Four articles in *African Arts* are: "The Yoruba Master Drummer," by Ayo Bankole, Judith Bush, and Sadek H. Samaan (Winter 1975, pp. 48–56, 77–78); "Professionals and Amateurs: Musicians of Zaire and Obimo," by David W. Ames (Winter 1968, pp. 40–45, 80, 82–84); "The Politics of Music in Mali," by Charles Cutter (Spring 1968, pp. 38–39, 74–77); and "Comic Opera in Ghana," by E. J. Collins (January 1976, pp. 50–57).

Coconut Crabs (p. 76)

Ernst S. Reese discusses the importance of shell-carrying behavior in young crabs in "Shell Use: An Adaptation for Emigration from the Sea by the Coconut Crab" (*Science*, July 26, 1968, pp. 385–86). Gene S. Helfman's "Agonistic Behaviour of the Coconut Crab, *Birgus latro* (L.)" (*Zeitschrift für Tierpsychologie*, April 1977, pp. 425–38), with seven photos of crabs in different positions, offers an evolutionary explanation of differences in coconut crab and other hermit crab displays. Edward E. Held discusses the exoskeleton-eating habit of the coconut crab in "Moulting Behaviour of *Birgus latro*" (*Nature*, November 23, 1963, pp. 799–800). In an older paper, "On the Food Habits of the Coconut Crab (*Birgus latro* L.), with Notes on

ts Distribution" (*Archives Néerlan-laises Zoologie*, vol. 3, 1939, pp. 283–320), A. Reyne catalogs feeding habits and distribution and argues strongly that the crabs are unable to husk and open uninjured coconuts. Brian A. Hazlett's "Ritualization in Marine Crustacea," in *Behavior of Marine Animals, Current Perspectives in Research, Volume 1: Invertebrates*, edited by Howard E. Winn and Bori L. Olla (New York: Plenum Press, 1972, pp. 97–125), explores stereotyped behavior patterns in hermit crabs. For a discussion of the adaptive significance of snail shell use by aquatic hermit crabs see Ernst S. Reese's "Behavioral Adaptations of Intertidal Hermit Crabs" (*American Zoologist*, May 1969, pp. 343–55). Shell availability among terrestrial hermit crabs is treated in Syd Radinovsky and Alex Henderson's "The Shell Game" (*Natural History*, December 1974, pp. 22–29). The American Zoologist Symposium "Terrestrial Adaptations in Crustacea" (*American Zoologist*, August 1968, pp. 307–685) contains several papers on the problems faced by an aquatic lineage of animals adapting to a terrestrial existence (*see* Dorothy E. Bliss's "Transition from Water to Land in Decapod Crustaceans," pp. 355–92). Laurel R. Fox treats the social and ecological conditions under which cannibalism has been observed and might be expected to arise in animal populations in "Cannibalism in Natural Populations," pages 87–106 of the *Annual Review of Ecology and Systematics*, volume 6 (Palo Alto: Annual Reviews Inc., 1975). Charles Darwin comments on size, strength, and purported nut-opening techniques of the crab in *The Voyage of the Beagle* (Garden City: Doubleday and Co., 1962).

Katharine D'Agosta

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Breakfast at Shungopavi

Blue corn is an essential ingredient of traditional Hopi cuisine

They don't sell tickets to the Niman dance. There are no posters for it slapped on the walls of the pueblo villages, and not even the weekly paper, *Qua 'Toqti, The Eagle's Cry*, "serving the Hopi Nation," mentions when Niman—the last and most important kachina ceremony of the season, celebrating the gathering-in of the first ears of corn from the parched fields—will occur at Shungopavi and Bakabi. The only way to find out about this ritual is to ask a Hopi, and even that is no simple matter. The handful of telephone lines that connect the remote, high Hopi mesas in northeastern Arizona with the outside world are almost always busy. But word gets out. On the eve of Niman, the Hopi Cultural Center's motel, a modern version of traditional Hopi village architecture on Second Mesa, is booked solid with Indian buffs, transcendental meditators, and European tourists doing the grand tour of *le Far West.*

To protect their ancestral culture from twentieth-century, high-tech rubbernecking, the Hopis forbid photography, sketching, and recording in their villages. You can buy a kachina doll, carved from cottonwood root and originally intended to help Hopi children learn about the elaborately masked and feathered, sashed and buskined supernatural beings who are impersonated by members of the Kachina Society at the various dances. But the dolls are meager preparation for the real kachinas.

Without warning, they file into the plaza at Shungopavi, moving slowly and with the precision of Rockettes, chanting, consecrating the ground of the plaza with cornmeal, while an eagle chained on a nearby rooftop flaps its wings. Around the edge of the plaza and on the flat roofs that overlook it, Hopi and non-Hopi spectators sit in rapt absorption. The mysterious force of the Niman holds everyone. For a few moments, after the kachinas file out and disappear into the underground houses called kivas, it is impossible not to feel the power of a ritual that has been practiced since before Columbus, when Hopis built what is now the oldest continuously inhabited town in the United States at Oraibi.

Then the tension breaks. Hopi children scamper through the plaza holding ears of corn, one of the special food gifts of the day. Another edible present is piki—a brittle, thin toasted bread made from cornmeal. Piki is the highest expression of Hopi cuisine and the most intricate symbol of the intertwining of traditional Hopi life with corn.

There is nothing quite like it. Hopis compare piki to corn flakes; it tastes as corn flakes would if they were unsugared and unsalted. But piki is cooked in big papery sheets, then rolled up tightly into eight-inch-long cylinders about two inches thick. Also, and crucially, piki is blue.

Sometimes, it is true, piki is baked from white cornmeal and then dyed red and yellow. But standard piki is slate blue, the glory of a prescientific culture whose caprice was to glorify a genetically freakish corn with kernels the color of the sky.

Indian corn comes in most of the colors of the rainbow because of pigmentation in the pericarp and aleurone layers of the kernel. Paul Mangelsdorf, the dean of American corn scholars, once wrote that the multicolored corns of our Southwest were part of a lineage that could be traced back to Peru and had been cultivated for centuries throughout Indian America. The original strain is called *kculli.* Prehistoric remnants of it have been found in former Inca territory, and it still grows in the high Andes. In its pure blue form, this corn is still widely cultivated in the American Southwest and milled

A street in the Hopi town of Shungopavi, the site of this year's Niman dance, as it looked in 1901.

by Raymond Sokolov

Adam Clark Vroman From a private collection

A turn of the century photograph of a pueblo interior shows women grinding corn into flour.

commercially for Indian consumption in Arizona and New Mexico. Blue tortillas and other blue breads appear in Navaho and Pueblo cooking, perhaps as part of some general fascination with the blue of heaven. An outsider, wondering about the importance of blue to the Indians of the desert, will find ample impetus for symbolic interpretation in the omnipresent turquoise jewelry and blue-dyed clothing.

The truth, it seems, is simpler. "It's pretty," one Hopi told me. Others supported him. Blue is an attractive color. Symbolic explanations do not appeal.

Because of this aesthetic bias and the paramount significance of maize, foods made from blue corn, and piki, in particular, are as important to Hopi culture as the kachina ceremonies, the communal architecture of the mesa villages, and the Hopi language. All of these tribal peculiarities mark off the 8,000 ethnic Hopis from the rest of the world and give them an identity that has allowed them to survive in modern America as a distinct people entirely surrounded by unfriendly and more numerous Navahos.

"They say no man will marry a girl unless she can make piki," wrote Helen Sekaquaptewa in her autobiography, *Me and Mine*. At 81, she is the grande dame of Hopi women, mother of the tribal chairman and a revered spokesperson for Hopi tradition, despite her modern education and broad experience off the reservation. Her life exemplifies the conflict between tradition and assimilation in recent Hopi history. Her parents were "traditionals" and hid her so that she would not have to go to the *bahana* ("white man's") school. Eventually, the truant officer found her and dragged her off to a schoolhouse in Keams Canyon at the edge of Hopiland, where they deloused her, dressed her in *bahana* clothes, and taught her English. Helen Sekaquaptewa turned out to like school, but in 1910, she came back to Oraibi for a year at home and learned "the things a Hopi girl should know." Piki was one of the main lessons.

First, she learned to make the stone piki griddle, starting with a granite slab and polishing it smooth, by hand, with pebbles. She also ground corn into flour, working it between two stones, one held in the hand, until she produced a very fine blue flour, much finer than the meal one sees today in Indian supermarkets. "We have electric mills now," she says. "It was hard work in my time, with stones, but good exercise. No one had a big stomach."

The old technique of hand grinding is still handed down from mother to daughter. Young women have to grind flour in the traditional way as part of the preparation for marriage. But stone grinding is no longer a part of normal life. In a recent editorial in *Qua 'Toqti*, Mrs. Sekaquaptewa's son Wayne, the paper's editor-publisher, fulminated against milling machines, the "iron daughters-in-law" that were, he said, sapping Hopi culture of its vigor.

The Hopi ritual calendar, however, has helped to keep traditional piki making alive. Before the Niman dance this summer, women were busy in special piki rooms, building fires under piki stones. They sat in front of the red-hot stones, rubbing melon seeds over them until the oil came out and greased the stone. When the stone had cooled to a moderate temperature, the women

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made piki batter from blue corn flour, water, and an infusion of ashes from greasewood (*Sarcobatus vermiculatus*), a shrub that accentuates the batter's blueness and gives it a characteristic flavor. Before actual cooking begins, the stone is lightly greased once more with a piece of cooked sheep's spinal cord. Then the women spread batter thinly on the stone, a little at a time until the stone is covered. As it cooks, the sheet begins to peel away from the stone, like a crepe, and can be pulled off by hand. The first sheet is discarded. As subsequent sheets cook, they are covered with a finished sheet of piki. The steam from the raw sheet underneath softens the top sheet enough so that it can be quickly rolled up and set aside on a mat.

The process is similar to the one used to make Chinese spring roll skins and the Moroccan leaf pastry called *warka*, but piki is even more intricate and sophisticated in method, while at the same time more primitive. The steaming and rolling stage is unique in its culinary refinement. The hand spreading of batter on a hot stone harks back to a stage of cultural development before metal was known. All in all, it is hard to think of a recipe that demands more skill from a cook or that displays more ingenuity with simple materials.

Precisely because of its complexity, piki is the epitome of a food that cannot be made without a steady flow of cultural apprenticeship from one generation to another. In this respect it is the opposite of steak and hamburger, dishes that can be taught in minutes and which can infiltrate foreign cuisines with the ease of a virus invading a bacterium. Hopi blue corn cookery, however, is full of such culinary shibboleths that a *bahana* cook will have trouble duplicating a dish, even with a recipe and plenty of blue cornmeal on hand.

Mrs. Sekaquaptewa recently demonstrated to me an "easy" Hopi breakfast dish called *pö-vö-pi-ki*, or blue marbles (see recipe). She made a straightforward dough and then rolled it into small blue orbs, which she then

The typical Hopi maiden of the early 1900s possessed cooking skills unknown to Hopi girls today.

Adam Clark Vroman Courtesy Southwest Museum, L.A

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poached. To get the texture right is a matter of exquisite judgment. No recipe can give exact quantities.

She went on to make an elegant poached corn bread called *tsu-ku-vi-ki*, V-shaped packages of blue dough wrapped in moistened corn husks that held the dough together until it had cooked. After cooling, the breads solidified into their boomerang shape. Tying the raw dough up in the cornhusk packages, so that they hold together and look right, is a knack not easily learned at one sitting. It took Helen Sekaquaptewa a week when she was a girl. Today's Hopi girls may learn these tricky techniques when they marry, but they rarely use them in daily life. Consequently, older Hopis like to drop in for a visit at Helen Sekaquaptewa's house, because they know they will find traditional food there that their younger family members don't make for them. Mrs. Sekaquaptewa says: "We still eat the old food when we are hungry for it. My son Abbott [the tribal chairman] travels all over the country eating *bahana* food. He gets hungry for this and I make it for him."

While Mrs. Sekaquaptewa cooked and talked and remembered, in the modern kitchen of Abbott's ranch house in New Oraibi, her granddaughter Allison helped her at the stove. Allison, in corduroy jeans and Adidas sneakers, had obviously never cooked blue marbles or *tsu-ku-vi-ki* before. Will she learn how to make either, or piki, in the course of her ritual education? In theory, she will. But the television in her living room is teaching her other, easier lessons. Convenience foods fill the supermarket in New Oraibi. Disco evenings compete with the kachina dances. No doubt, the Hopis can survive without their religion or their piki but, as an old kachina doll carver in Shungopavi asked me, "Will they still be Hopis?"

Blue Marbles

(*Pö-vö-pi-ki*)

1½ cup blue cornmeal (see note) or ½ pound, approximately
2 tablespoons ashes from burned bean leaves or sagebrush or substitute 1 teaspoon baking powder
2 tablespoons wheat flour

1. Bring 2½ quarts of water to a boil in a large pot.
2. In a large mixing bowl, divide the blue cornmeal into two separate mounds, one about 1¼ cups, the other ¼ cup.
3. Scald the larger mound of cornmeal with about ½ cup of boiling water or just enough to moisten it throughout. Stir the moistened flour as you add the water.
4. In a small bowl, stir the ashes together with 1 cup boiling water. Push the mixture through a fine strainer, then add gradually to the cornmeal along with the wheat flour. If you are using baking powder, simply mix it into the cornmeal in step three and then moisten the cornmeal with about one cup boiling water. Let cool until you can handle it comfortably.
5. Add additional dry cornmeal from the smaller mound to the dough as you work it. Use only enough to produce a smooth, workable dough. The end product should be gray blue and elastic. (Reserve any unused dry flour for future use.)
6. Break off a piece of dough and roll it into a long coil about 1 inch in cross section. Break off small pieces from this coil and roll them into balls the size of cherry tomatoes. With practice you will be able to roll two at a time between your hands. (If the dough is too sticky to work, add more cornmeal.) Continue until you have used up all the dough.
7. Spoon the blue marbles into the pot of boiling water. When they are all in, pour off any excess water, leaving just enough to cover them.
8. Simmer slowly, uncovered, for 8 to 10 minutes. Remove from water with a slotted spoon. Cool.
9. Serve the blue marbles in their cooking liquid for breakfast. Accompany them with stewed fruit, hard-boiled eggs and raw onion, or fried (dried) chilies.

Yield: 3 to 4 servings

Note: Blue cornmeal is available in supermarkets throughout the Southwest. It can be ordered by mail from Casados Farms, P.O. Box 852, San Juan Pueblo, N.M. 87566. Anyone with access to an electric grain mill should grind commercial blue cornmeal to the fineness of flour before making this recipe.

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

Helen Sekaquaptewa holds coils of blue cornmeal dough as she demonstrates traditional Hopi cooking.

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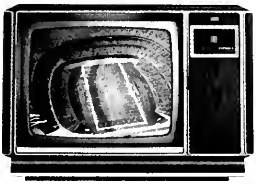

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Incorporating Nature Magazine
Vol. 88, No. 10 (ISSN 0028-0712)
December 1979

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Cover: *Seven to ten days after spawning, threespine stickleback eggs are beginning to hatch. Photograph by Dwight R. Kuhn (turned so that top is at left). Story on page 32*

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Authors

A physical chemist, **R. Stephen Berry** became interested in nonrigid molecules and clusters in 1956. The first of his many research papers on the subject was published in 1959–60, and he has worked on and off in that field ever since. A professor of chemistry at the University of Chicago, Berry is also a member of the James Franck Institute and the Committee on Public Policy Studies. In addition to his teaching and research, he is on the board of directors of the *Bulletin of the Atomic Scientists* and is "rather deeply involved in studies on energy, environment, and other physical resources." Berry was elected to membership in the American Academy of Arts and Sciences last May. Born in Denver, he has never lost his love of the mountains. He summers at the Aspen Center for Physics where he can spend his free time hiking, climbing, and trout fishing.

A consulting entomologist, **William H. Jordon, Jr.**, is hard at work on his second book, *Adam and Eve Through a Bug's Eye.* He describes the text as a "tongue-in-cheek look at the human condition from the distant view of the entomologist steeped in insect behavior." Jordon, who received his doctorate in entomology from the University of California at Berkeley, has done four years of fieldwork throughout California on alfalfa weevils and their wasp predators. His plans include making documentary films on insect ecology and ethology and— when he gets the chance—some serious sailing.

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Marcello Truzzi was born into the circus—his father was the internationally famous juggler Massimiliano Truzzi. Department head and professor of sociology at Eastern Michigan University, the author has written sociological pieces on the circus. "A general interest in the bizarre" has led Truzzi to study popular culture, man–pet interactions, and claims made of the paranormal. He juggles as an avocation and is a member of the International Jugglers Association.

At a seminar on Puerto Rican birds, **Thomas A. Wiewandt** first learned of the existence of Mona Island, located between Puerto Rico and the Dominican Republic. Intrigued by the island's research possibilities he took a job as the resident ecologist there for the Puerto Rico Department of Natural Resources. During the three years he held the position, he became intimately acquainted with the huge Mona Island iguana. A free-lance environmental consultant and photographer, Wiewandt won a first prize in the 1976 "Natural History Photographic Competition." He has recently revised and narrated "Voices of the Night," a recording made by the Cornell Laboratory of Ornithology that features the calls, distribution, and breeding habits of all species of frogs and toads in eastern North America.

David John Thomas encountered the colorful, independent diamond miners of Venezuela while doing research for his doctoral dissertation in anthropology at the University of Michigan. Now assistant professor of anthropology at Vanderbilt University, Nashville, Tennessee, Thomas plans to return to Venezuela in 1980 to investigate the effects, since 1970, of missions, mines, and migration on the country's Pemon Indians.

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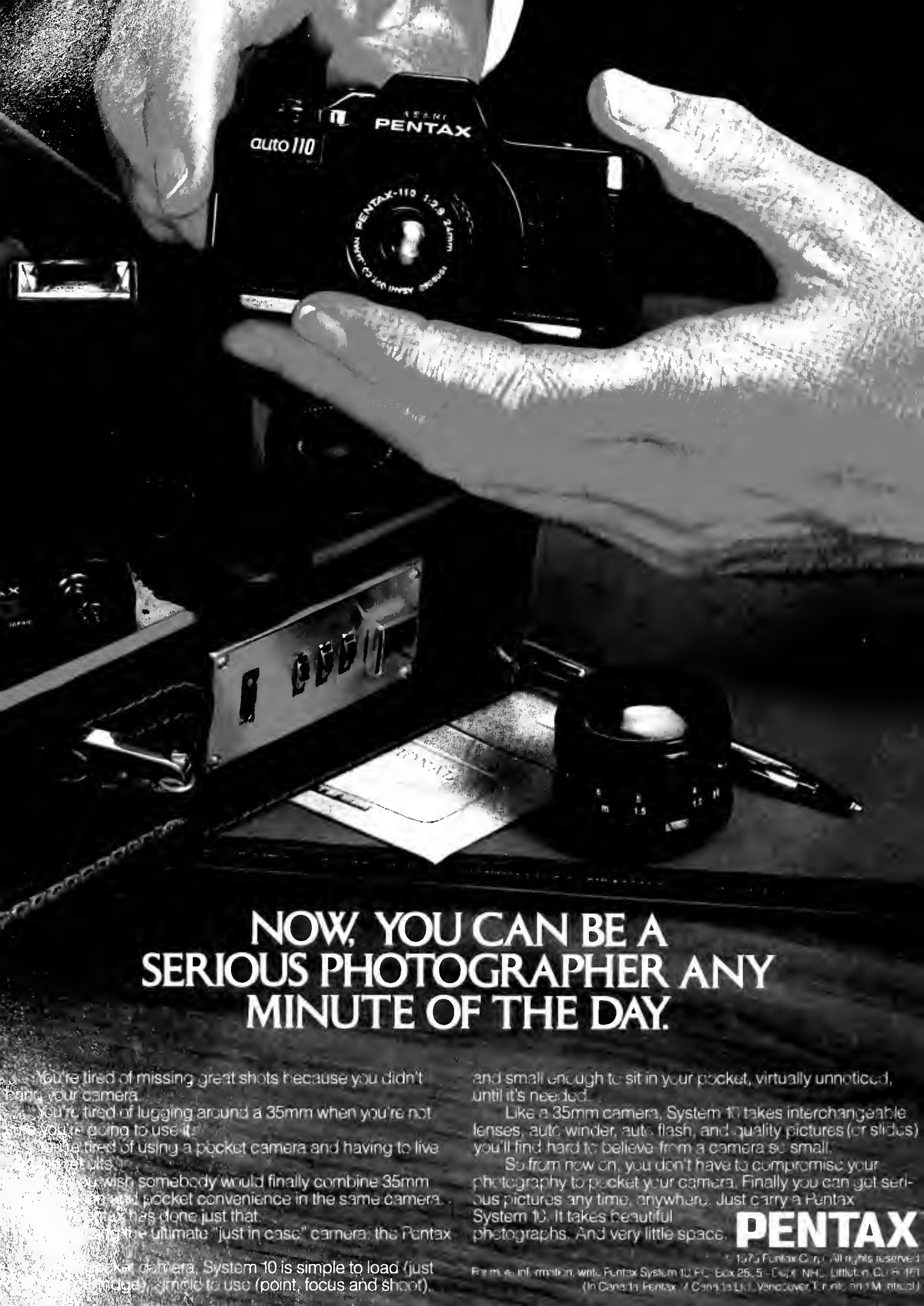
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During a decade, dedicated "birders" censused 635 million birds at Christmas. Was it worth the effort?

The Christmas "side hunt" is one of the most forgettable of early American holiday traditions. During this event, teams of shooters would compete to kill the largest numbers of wild birds and mammals on Christmas Day. The tradition persisted at least through the late nineteenth century.

The side hunt was particularly troubling to ornithologist Frank M. Chapman, who served the American Museum of Natural History for fifty-six years (twenty-two as chairman of its ornithology department); he also established and edited *Bird-Lore*, an official Audubon Society publication, from its inception in 1899 until 1935. In the latter capacity Chapman proposed, in October of 1900, an alternative Christmas side hunt—one in

Frank M. Chapman, Colombia, 1913

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which participants would count, rather than shoot, birds in their local areas.

Twenty-five "Christmas bird censuses" took place that year and *Bird-Lore* published the results the following February. Chapman hoped the data would be useful "because they give a very good idea of the distribution of winter birds on Christmas day, with some indication of the number of individuals which may be observed in a given time."

From these modest beginnings the Audubon Society Christmas Bird Count has grown into an annual ornithological outing of amazing proportions. Each Christmas count is a daylong census, conducted on or near Christmas Day, of all birds found within an area fifteen miles in diameter. Published results include lists of species seen and their numbers, latitude-longitude coordinates of the census areas, and numbers of hours afield and miles traveled as measures of census effort.

Thousands of observers participate each year in hundreds of censuses conducted mainly in the United States and southern Canada, but ranging from Central America to the Arctic. The Christmas count issues of *American Birds* (descendant of *Bird-Lore*) probably make up the largest collection of raw ecological data in existence anywhere.

Has it all been worth it? In one respect the question is irrelevant since count participants find the activity intrinsically interesting and self-educating. But surprisingly, Christmas count data have, in fact, been relatively little used. Individual scientists rarely can work long enough or widely enough to understand fully the relationships between species and their environments. Christmas count data would therefore seem to have enormous potential since they would allow us to examine changes in bird populations through both time and space on a continent-wide scale.

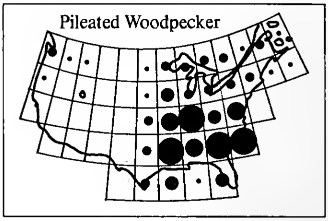
This potential has not been fully realized for two reasons. First, the sheer mass of the information. Anyone interested in a particular species must sift an enormous amount of chaff to obtain a small amount of wheat. Second, considerable—and perhaps justifiable—skepticism about the quality of the data, which is gathered mainly by "amateurs" using casual, that is, non-quantitative, methods compared with those biologists normally use to study local populations of particular species.

But the value of Christmas count data would lie in their quantity and not their quality. With this in mind, six years ago my students and I began using the count data to study North American winter bird populations. Computers are ideally preadapted for the problem of sorting wheat from chaff. For the same reasons that they cannot think, computers have an infinite tedium tolerance for sorting and manipulating lists of numbers.

With help from the National Science Foundation, we constructed a computerized data bank containing the results of 8,092 bird counts between the winters of 1962/63 and 1971/72. The data bank represented sightings of about 635 million birds, the result of well over one million observer-hours of fieldwork. We could then ask the computer to extract from the data bank only those pieces of information useful to a particular study. The computer also can manipulate the data, for example, dividing numbers of a species seen by the total hours spent on each count in order to standardize results in proportion to count effort.

We have found that the Christmas count can provide highly valuable information on North American winter bird populations, although the data must be used carefully and conservatively. Both rare and highly social species present problems because misidentifications or chance encounters of enormous flocks can seriously bias results. But for familiar and well-dispersed species we have been able to monitor population fluctuations and abundance patterns on a scale rarely possible for other sorts of animals.

A central hypothesis in our current

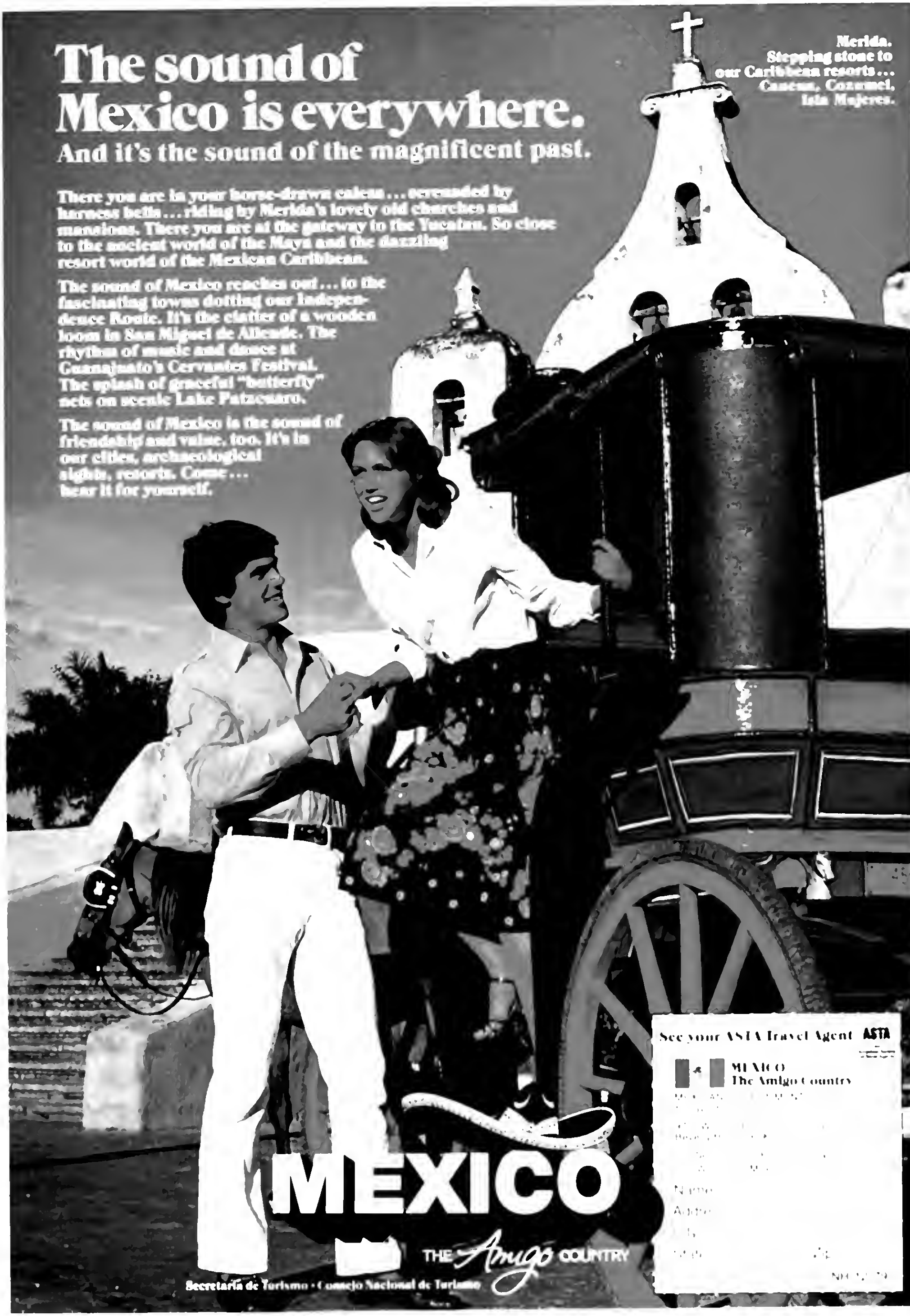


work is that important geographical boundaries of many species are marked by changes in the abundances of birds rather than by the known limits to their distributions. Birds are so mobile and so conspicuous, and ornithologists (both professional and amateur) so numerous and so enthusiastic in their pursuit of "new records," that most bird species are reported in all sorts of places where they do not "belong." New discoveries of single, perhaps erratic, birds continually increase the known ranges of species.

With Christmas count data we are not obliged to define major biogeographic boundaries and regions in terms of absolute ranges of species. Range limits probably are not the most important measures of a species' relationship to its environment (flying birds have the *potential* for getting almost anywhere). Instead, we can determine abundance patterns from Christmas count data. We have the opportunity, unique to science, of measuring abundances of a large number of species across an entire continent, and of using these data to describe the geography of that continent.

The power of this approach can be illustrated by the following analysis of

Frank M. Chapman (self-portrait), Panama, 1931 AMNH



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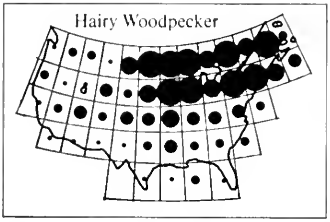
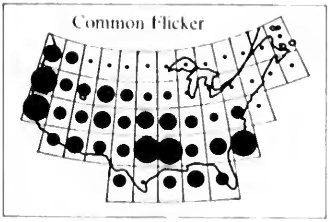


birds in the family Picidae—woodpeckers and relatives, the flickers and sapsuckers. Species in this family are well known, easily identified in the field, and usually rather evenly dispersed across the landscape. All of this makes them well suited for a Christmas count study.

As with most of our investigations, we first sorted counts into groups falling inside geographical blocks bounded by five-degree intervals of latitude and longitude. The forty-eight contiguous United States and a portion of southernmost Canada lie within fifty-one such blocks. Counts are rare farther north. We next computed the average numbers of each species seen per hour of count effort, for all counts in each block.

The hairy woodpecker and common flicker occur in nearly all blocks, meaning that their early winter ranges are about the same, but their abundance patterns differ strikingly. The hairy woodpecker reaches highest densities in the cool and moist forests of the northeast, while flickers concentrate in just the opposite parts of the country, especially the warm southeast and along the Pacific coast. The familiar red-headed woodpecker is considered a typical eastern species, but Christmas count data show that it is much more common in the midwestern states. The ladder-backed woodpecker is widespread across the Southwest but reaches highest densities in scrub habitats of southern and western Texas.

The maps, then, tell us much about the ecologies of different species. But more importantly, using mathematical techniques we can reveal those biogeo-



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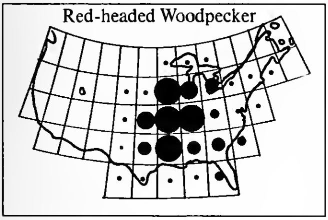
graphic boundaries where major changes in woodpecker faunas occur. The line that separates woodpecker species into eastern and western blocks is the most profound geographical boundary anywhere in the United States, at least for woodpeckers. This boundary lies along the eastern border of Montana, jogs east, continues south through South Dakota, Nebraska, and western Kansas to south-central Texas, and then east toward Louisiana. Over most of this distance the boundary is coincident with longitude 100 degrees west.

In addition the eastern group divides into distinctive northeastern and southeastern clusters. The western block rather quickly divides into southern Texas and Arizona versus everything else.

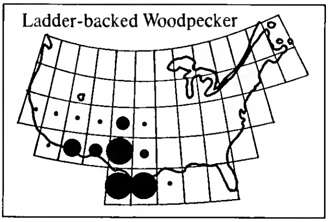
If you asked Americans where they think the "west" begins, most would probably say that it starts at the foothills of the Rocky Mountains in a north-south line running through east-



ern Wyoming, central Colorado, and New Mexico. Certainly this is the most conspicuous geographical boundary in the United States. Yet that line, at about longitude 105 degrees west, is not where woodpeckers think the west begins. The major break in woodpecker faunas occurs well east of the mountains, out on the plains at about longitude 100 degrees west.

What environmental factor could be causing this shift? In fact, woodpecker Christmas count data highlight the true nature of the east–west transition in North America—that of decreasing moisture. The geographer and explorer Maj. John Wesley Powell recognized the nature of the western United States as a land where one had to irrigate to grow crops and forage. W.C. Darrah, a Powell biographer, noted: "The Major was the first to recognize the real boundary between East and West, between humid and arid. . . . This line coincided approximately with the hundredth meridian."

In the 1870s Powell attempted to change American homesteading laws to reflect this environmental gradient across the plains, near the hundredth meridian, but his insights were unappreciated and generally ignored by Congress, dominated as it was by easterners ignorant of western water problems. Much of the subsequent mismanagement of western lands and natural



resources can be traced to the persistence of this difficulty, even to the present day.

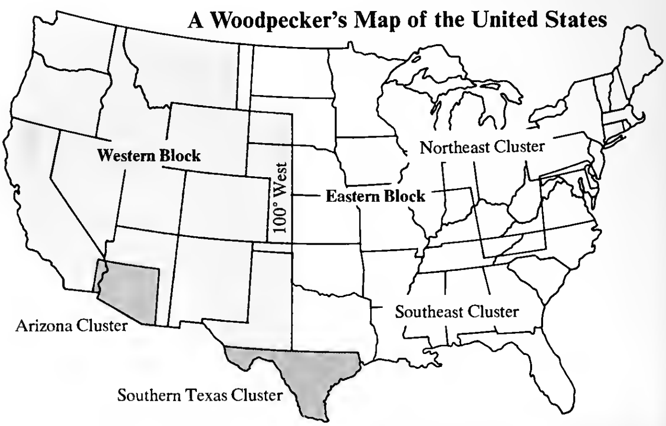
The other woodpecker boundaries correspond to better-known environmental changes. The line separating the northeast from the southeast coincides closely with the maximum southward extent of glacial ice during the Pleistocene epoch, and with the modern boundary between temperate climate forests in the north and subtropical forests in the south. The boundary dips down along the Tennessee-North Carolina border, indicating the northern affinities of woodpeckers in the heart of Appalachia. The species dominating southern Arizona deserts and southern Texas, such as the gila, golden-fronted, and ladder-backed woodpeckers, are essentially Mexican forms, which accounts for the distinctness of these regions from the rest of the west.

This has been one example of the value of Christmas count data in studying the North American environment. Others could have been chosen. Birds, because of their mobility and sensitivity, are particularly good barometers of environmental change, including changes imposed by humans. A comprehensive national census such as the Christmas count can serve as an early warning system of future environmental perturbations caused by suburbanization, intensified agriculture, or exploitation of nonrenewable energy sources.

True, Christmas count data are gathered mainly by amateurs, but in some respects that is a positive attribute. Most participants are serious "birders": they know their organisms and their particular count areas, and they are painstakingly honest in reporting results.

While these data cannot be used to solve the energy crisis or to cure the common cold, they can do a lot. We have computerized and analyzed, only partially so far, the product of a truly Herculean field effort. That effort could not be matched by professionals without the expenditure of millions of tax dollars. Christmas count data are free, gathered by the people, and we are fortunate to have them. Frank Chapman's wise alternative to the Christmas side hunt has become a gift to science.

Carl E. Bock, who enjoys the Christmas bird count, is a professor of biology at the University of Colorado.



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The old notion that molecules are rigid structures has become a paradigm lost; some are rigid but some are floppy

by R. Stephen Berry

Since the advent of modern structural chemistry in the second half of the nineteenth century, the paradigm of molecular structure has been overwhelmingly the stable, almost rigid object. We think of molecules as tiny versions of models we could build by connecting knobs with sticks or springs. This notion has worked well. Nearly all the molecules known, apart from long, chainlike ones such as those that make up rubber and polyethylene, can be described as atoms arranged in permanent geometric structures. With modern laboratory methods, their structures can be established with great precision. Almost everything else, from the smallest objects—atomic nuclei and the quarks from which we think those nuclei are made—to the cosmic clusters of galaxies, is fluid, dynamic, and changing.

The most familiar of these loose structures are ordinary liquids and gases, water and air. Molecules and crystals are the exceptions; only they fit the picture of knobs, representing atoms, connected by sticks, representing chemical bonds. The knobs quiver, vibrating just a little bit about their average positions in the molecular skeleton. And the whole Tinkertoy—molecule or crystal—may rotate in space, a rigid, spinning structure. The technical terms used for such objects reflect their properties: most molecules are called rigid rotors with small-amplitude vibrations.

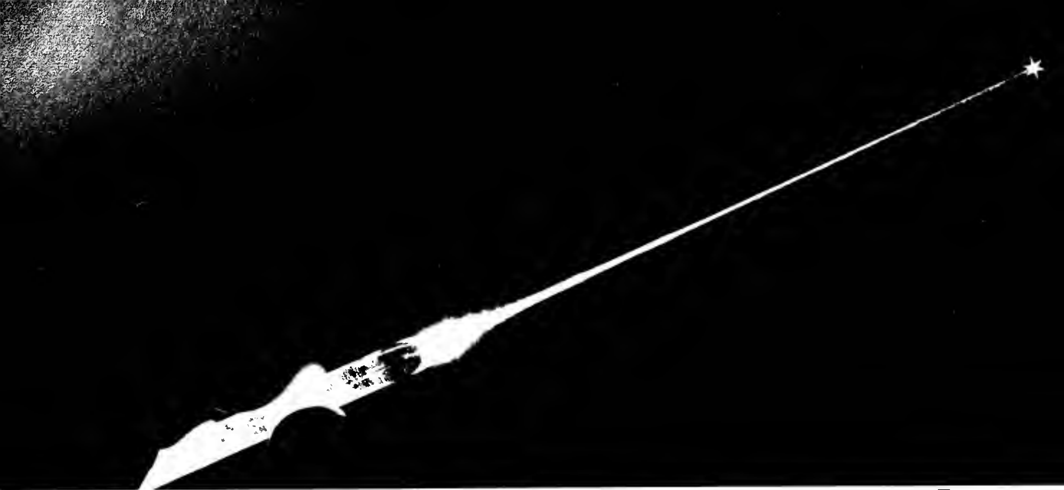
By conceiving of molecules this way, scientists constructed a relatively simple theory of their behavior. From it, we have been able to make innumerable, remarkably accurate deductions and predictions about molecular structures and about the amounts of energy that molecules may store in the form of rotational and vibrational motion. Molecular spectroscopy, the study of the exchange of energy between molecules and light, is probably the most self-consistent and verifiable body of quantitative knowledge yet achieved. It is awesome, in retrospect, that we have been so successful.

Why is it that only molecules and crystals, which we usually think of as giant molecules, have such permanent structures? In galaxies, fluids, and atomic nuclei, the components (stars, molecules, and protons and neutrons, respectively) move more or less freely throughout the entire interior of the parent structure, yet the galaxy, the drop of water, and the nucleus of the atom cling together. In all the cosmos, are molecules unique in having permanent structures?

As we studied the structures of more and more of the vast number of molecules, we found that there are interesting and important molecules that do *not* conform to the traditional rigid Tinkertoy model. When these were found, the study of molecular structure lost its unique simplicity and joined the other fields, from particle physics to astronomy, in which scientists have been wrestling with the description of nonrigid clusters. The languages and even the laws of mechanics differ, but the conceptual problem, called the many-body problem, is nearly the same in all fields of physical science, whether one is trying to describe quarks in a proton, neutrons and protons in a nucleus, electrons in an atom, molecules in a droplet, planets in a solar system, or stars in a galaxy. And now, where there seemed to be a gap in the middle of the list, we must add atoms in the nonrigid molecules.

One of the first molecules recognized as nonrigid is ammonia, NH_3, which has the form of a pyramid with the nitrogen atom at the peak. The nonrigidity of this molecule is of a very special, limited kind: ammonia turns itself inside out like an umbrella. The three light hydrogen atoms occasionally pass by the heavier nitrogen atom, inverting the pyramid. "Occasionally" means about ten billion times a second—fast for us, but slow compared with the ordinary vibrational motions of the hydrogen atoms, which quiver back and forth about ten trillion times per second in their motions. In other words, roughly once in every thousand oscillations, the three hydrogens of ammonia slip past the nitrogen in a concerted excursion that carries them across the molecule. (If the hydrogen atoms of ammonia are replaced by deuterium atoms, having the same chemistry as the simple hydrogen atoms but twice the mass, the pyramid inverts at a rate of only about half a billion times a second.) This process in ammonia is responsible for the particular mechanism for absorption and emission of microwave energy that gave rise to the first maser ("maser" is an acronym for "microwave amplification by stimulated emission of radiation"). And the laser (light, instead of microwave) developed from the maser.

Two sorts of nonrigid molecules can be distinguished. Examples of one ex-



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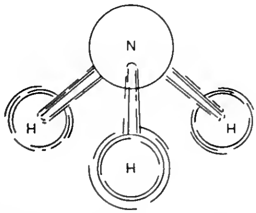
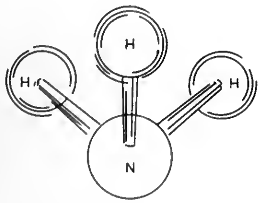


The nonrigid ammonia molecule, NH_3, above, has the heavy nitrogen atom at the top and the lighter hydrogen atoms at the bottom. The hydrogen atoms vibrate continuously in their positions, and about ten billion times a second they slip past the nitrogen. On those occasions, the molecule turns inside out like an umbrella, below.



Alan Iselin

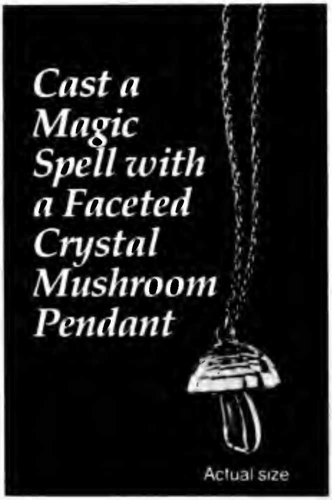
treme are ammonia, phosphorus pentafluoride, and the triatomic sodium molecule Na_3; atoms move about in the molecules of these substances no matter how little energy they have. Moreover, the distances between the atoms in these molecules are about the same as the sizes of the atoms themselves, so the molecules contain little empty space. At the other extreme are molecules containing so much energy that the atoms can almost—but not quite—escape from each other. The atoms in these molecules, like the planets in the solar system, may spend most of their time far from one another.

The first kind of nonrigidity occurs when solids melt and when phosphorus compounds react in living systems; the second, which has only recently begun to be explored, may be important for the formation of molecular clusters in the "dark clouds" of the interstellar medium, the vast masses of material in the space between the stars of the galaxies, which we believe eventually condenses to form new stars. The growth of clusters of molecules into droplets and of droplets into liquid drops or solid crystals falls between the two: in the earliest stages and in a rarefied medium such as interstellar space, the model of a transient, fragile bundle of almost-free atoms may be appropriate. Later, when the droplet reaches adolescence, the fluidity of a liquidlike cluster is a more realistic description.

Let us look more closely at one of the simplest molecules that illustrates the general symmetry principle of nature central to the subject of nonrigidity. Ozone, with the formula O_3, has the shape of an isosceles triangle; its spectrum makes this incontrovertible. We know this substance well indeed; we inadvertently produce it in the smog of urban atmospheres, where it generates eye irritants and destroys rubber. At the same time our technological wastes threaten to decompose it up in the stratosphere, where it provides a protective blanket, absorbing most of the harmful part of the sun's ultraviolet light.

Apart from its roles in the lower and upper atmosphere, the simple ozone molecule presents the physicist with a dilemma of the most fundamental sort. Because the O_3 triangle is isoceles and not equilateral, the two oxygen atoms at the ends are chemically identical, but the third, occupying the unique middle site, is chemically different and therefore distinguishable from the end two. But all oxygen atoms are supposed to be indistinguishable. Their indistinguishability is a special case of one of the most general hypotheses on which modern physics is based: that atomic or subatomic particles of a single kind—electrons, protons, or atoms of a single isotope of any element, for example—must be indistinguishable if they are in a stable, stationary state.

This hypothesis states that we can never find an experiment that will distinguish one electron from another, provided they are in the kind of equilibrium known as a stationary state. Within an atom or molecule, the electrons achieve that equilibrium—a dynamic equilibrium like that of the solar system, not a static equilibrium like a rock resting on the ground—in less than a hundredth of a trillionth of a second (10^{-14} second) after the electrons are disturbed (by the passage of another fast electron, for instance). This corresponds to the time it would take electrons to make a few circuits of the nucleus if they were tiny charged particles in orbit, as Newton's classical mechanics would have had



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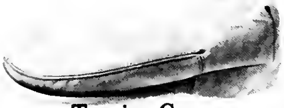

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them. The electrons become indistinguishable by exchanging roles with one another so rapidly that we cannot pick out which is closest to or farthest from the nucleus. More generally, nature always provides some mechanism for identical particles to achieve indistinguishability

The same rules of indistinguishability must apply to atoms of the same kind: the two atoms of hydrogen that make a molecule of hydrogen (H_2) cannot be told apart. The simple process of rotation allows them to change places and become indistinguishable. But most of our common experience tells us we can carry this idea too far; much of this indistinguishability must be utter nonsense. Surely the atoms in one glass of water are the same kinds as those in a glass next to it, but those in the glass on the left are obviously distinguishable from those in the glass on the right, simply because the two glasses are different. Furthermore there seems to be no way for the atoms in one glass to trade places with those in the other. The law of the indistinguishability of identical particles, supposedly so fundamental, doesn't seem to stand up to even the most casual test.

The paradox of the distinguishability of identical particles is not difficult to resolve if we look more closely at the condition required for indistinguishability: the system containing the identical particles must be in a state near enough to perfect equilibrium that the identical particles can exchange roles with each other several times during the time it takes us to observe them. Turned around, this statement implies that if we are able to catch snapshots of identical particles so fast that they do not have time to exchange roles among themselves, then we *can* distinguish identical particles from one another. The key to distinguishability lies in the ratio of the time required for a measurement to the time it takes particles to exchange. If the measurement time is shorter than the exchange time, the particles look as though they have permanent sites within the molecule, which allows us to identify them; if the time for exchange is the shorter, the particles look to us as if they all share all possible locations.

One of the fascinating aspects of the establishment of the indistinguishability of particles, called particle equivalence for short, is the enormous range of time scales spanned by the processes that accomplish this equivalence. In an atom, the particles that become indistinguishable are electrons; we saw that this equivalence establishes itself in about a hundred-trillionth (10^{-14}) of a second. The times for protons or neutrons to exchange with each other in a nucleus are even briefer. At the subatomic level, most of the exchange processes that establish particle equivalence occur too fast for us to detect them. But atoms in the two glasses of water would require a time much longer than the age of the universe to exchange with each other. Identical particles much bigger than atoms or molecules only exchange over time intervals of longer duration than any experiments we could ever perform. Even at the atomic level, the constituent atoms of most molecules remain in place for periods that are long by our daily standards; if they did not, the molecules would not maintain stable structures and the world as we know it could not exist. But at the atomic level, there are some processes of exchange and rearrangement whose rates are fast enough for us to see their consequences and slow enough for us to watch their progress. Molecules that rearrange at measurable rates are the molecules we sometimes describe as *floppy*.

The range of rates observable to us lies between about one rearrangement per minute and, with the help of modern ultrafast lasers, about ten trillion rearrangements per second. But in interstellar space, much slower rearrangements are possible. In that rarefied medium, where much of the matter of the universe lies, molecules may spend centuries between collisions. Out there, molecules that look rigid on the human time scale of years have eons in which to rearrange, so that equivalent atoms would seem to be indistinguishable to an observer who could watch even for centuries.

The quantitative measure of a molecule's floppiness is the rate at which it rearranges spontaneously. Determining these rates means looking into the molecule with a probe sensitive enough to respond to and record a dynamical process. Spectroscopy, the measurement of the characteristic energies that can be absorbed or emitted by each molecule, is the natural tool to use. Molecules have many ways of storing energy, but always in discrete units only; these discrete units are called the *quanta* of energy.

Some of the molecule's ways of storing energy, such as in the excita-

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tion of individual electrons from inner, normally occupied shells to outer, normally empty shells, require quanta of high energy, typically quanta of visible light or ultraviolet light of a shorter wavelength. Other ways molecules store energy are in vibrations, rotations, and the magnetic interactions between nuclei and external magnetic fields in which the molecule can be placed.

Among the slowest of observable processes are those we probe with the radio frequency, long-wavelength region of the spectrum. They are also the easiest to describe in terms of familiar, everyday concepts. Suppose a molecule contains hydrogen atoms. The nucleus of each hydrogen atom, a proton, behaves like a tiny magnet. If a vial of the material we are studying is inserted into the field of a strong magnet, each proton will behave much like a magnetic compass in the earth's field.

However, protons, electrons, and other elementary particles obey laws of quantum mechanics; one of these laws requires that a proton or an electron acting as a magnet has only two possible directions in which to point when it is in the field of a large magnet. The more stable, low-energy orientation points the proton's north pole toward the south pole of the large magnet. The less stable, high-energy orientation points the proton's north pole toward the north pole of the large magnet.

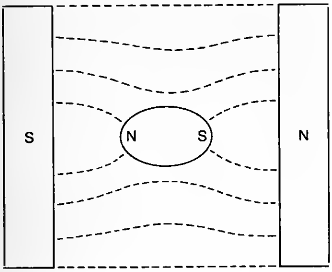
"High-energy" here means only a tiny bit higher than the "low-energy" orientation, an amount that corresponds to a quantum of radiation energy whose frequency and wavelength are those of a radio wave. The difference in energy of the two orientations, and the energy of the quantum equal to that difference, depend on the strength of the externally applied magnetic field; typically, the frequency of the radio waves is something between about 40 and 200 megacycles, roughly the range of FM radio.

Suppose a laboratory "broadcasting station"—known in the trade as a signal generator—is tuned to what is called the proton's "resonant" frequency. This means that the generator radiates quanta whose energy is precisely the energy separation of the two orientations of the proton. When this happens, the protons can exchange quanta of energy of the resonant radiation with the radiation field.

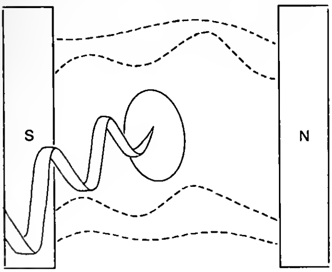
If the radiation from the generator is tuned to this resonant frequency, its force will push the nucleus ever harder until the nucleus flips into its other orientation. A different but analogous application of force at a resonant frequency is a singer breaking a glass by singing long and loud at the ringing frequency of the glass. The technique of studying protons by finding their resonant frequencies in the field of a large magnet is called "nuclear magnetic resonance," or NMR. It works with any magnetic nucleus.

NMR is useful for studying molecular structures because the magnetic field experienced by a proton in a molecule is not only the field produced by the large magnet; the local environment of electrons and protons also contributes. Sites that are different chemically almost always have different local magnetic fields. This means that the resonant frequency necessary to flip the orientation of a proton or any other magnetic nucleus depends on the chemical environment and the particular site of that nucleus. The technique of NMR has found its greatest use as a tool to probe structures, by identifying individual sites in molecules.

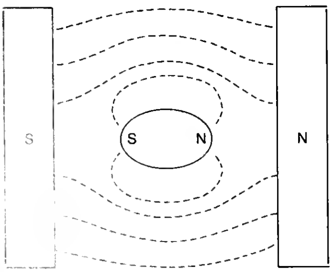
Imagine, as an example, a molecule with protons occupying two kinds of sites. If the molecule is rigid, then the protons are distinguishable because they are locked to one or the other of the two kinds of sites. Each site has its own local magnetic field and its own energies for the two proton orientations. This implies that we should observe two resonant frequencies at which protons could absorb radio frequency radiation, one corresponding to each of the two sites. The amount of energy absorbed by a bulk sample at one of these frequencies is proportional to the number of protons absorbing energy at that frequency. It therefore would be a direct measure of the number of protons occupying the corresponding kind of site. Thus we count the relative numbers of sites of each kind by measuring the relative amounts of energy absorbed at each resonant frequency.



This is the stable orientation of a hydrogen nucleus in a strong magnetic field.



This orientation changes when the nucleus absorbs a quantum of light whose energy equals the difference in energy between the nucleus's more stable and less stable orientations.



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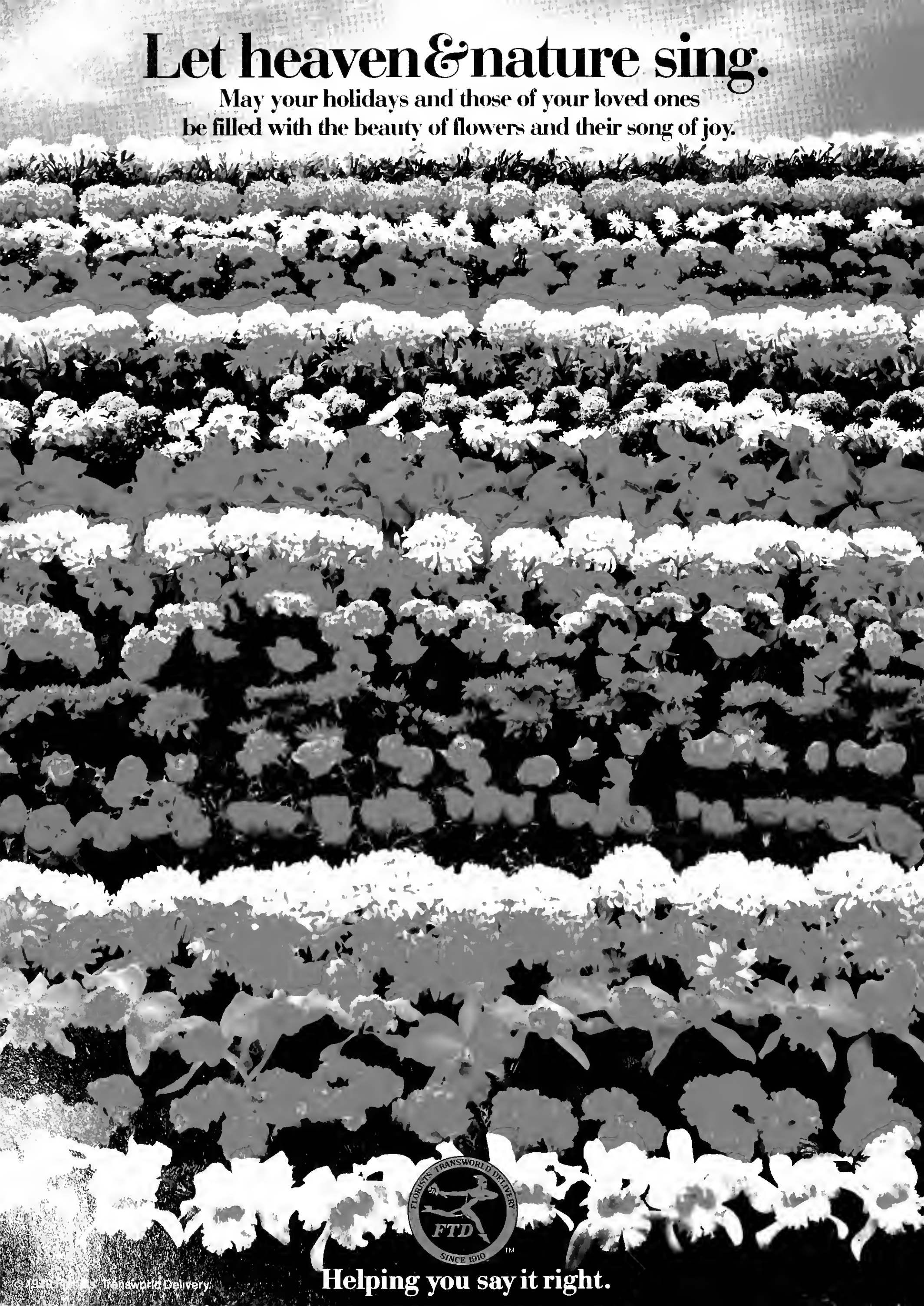
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Suppose our molecule is floppy and the protons move around. If the protons move fast enough, our detector will sense them as though they were all equivalent, and the local magnetic field experienced by each proton would be the average of the fields at all the sites. Our radio frequency spectrum would, in this case, consist of absorption of energy at a single frequency.

The floppiness of phosphorus compounds, crucial to all of life, is one of the most important instances of nonrigidity demonstrated by the NMR technique. Whenever a phosphate group attaches to or detaches from something else, the reaction makes use of the special floppiness that phosphorus compounds display when five atoms or groups are attached to a phosphorus atom.

Normally, when it is not undergoing a reaction, phosphorus has only four bonds, as in phosphoric acid and its phosphate salts. When the phosphoric acid enters into a reaction that will attach it to something else, such as a glucose sugar molecule, the four groups move to make room for the new neighbor. The glucose attaches as a fifth member of the group around the phosphorus in a position where a bond can form and break easily. But before the new fifth bond breaks, the molecule flops into a new form, putting the glucose in a position where its bond to phosphorus is strong. Meanwhile some other group of atoms moves to the weakly held site. Then that other group falls off and we find ourselves with a glucose phosphate. This appears to be the basic biochemical process for reactions of phosphate molecules, in the building of the chemical carriers of the genetic code of heredity and in the process that burns sugars in our bodies.

We have already made passing comments about the role of floppy molecules in the interstellar medium, most of which is empty. This role, in contrast to that of floppy phosphorus compounds in life processes, is still highly speculative. But examining our speculations is valuable because it tells us so much about the second kind of nonrigid molecules.

On the average, within our galaxy, there is about one atom or molecule per cubic centimeter. Between galaxies, matter is a million times more rarefied. But in some places there is enough matter to block starlight. Examples we can see are the dark clouds in the Milky Way. We believe that in these clouds, there are places where matter is con-

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densing, atoms are forming from ions and electrons, molecules and clusters are forming from atoms, and the density of matter is growing as particles come together and radiate away excess energy. Eventually, this matter collapses on itself and turns into a new star—or at least so we now believe. Here may be one of the places where floppy molecules play one of their most important roles. Just how they act in interstellar space is a question people are trying to answer.

When two atoms collide, they normally bounce apart. But sometimes they may orbit about one another long enough, in a sort of sticky collision, to give energy to a third passing particle or to emit radiation. In these ways the atoms can lose enough of their energy to make their compound stable. So far, this is part of the dogma of the theory of reactions in gases. The novel and speculative part concerns the nature of the newly born molecule.

We now realize that molecules in rarefied gases might exist for long periods in fragile states that have almost enough energy to break apart. In this condition, the component atoms vibrate slowly, spending most of their time very far apart compared with the distances that separate atoms in ordinary, stable molecules. These distances are a thousandfold greater, or even more, than typical chemical bond lengths. And the energies required to break up such molecules are very small, being comparable to the average energies of molecules in the interstellar medium. Such molecules have been found in the laboratory. But whether they exist long enough for us to observe them in space, and whether they are building blocks for stable interstellar molecules are open questions.

We believe that crystals are rigid and liquids are loose and floppy. How do clusters of a few atoms or molecules behave? Are they rigid and crystallike or floppy like liquid droplets? Might a cluster of atoms sometimes be solidlike and sometimes liquidlike? If so, then the problem of the structure of floppy molecules must merge into the problem of how molecules in a gas condense to form clusters and eventually become droplets or crystals.

Two kinds of evidence tell us that even very tiny clusters, made up of as few as five or six atoms or molecules, can be either solidlike or liquidlike. Thinking of a six-atom cluster as either a crystal or a liquid drop boggles the imagination of a scientist trained to think of solidity and liquidity as properties characteristic of very large aggregates. But if we approach the idea more naïvely, with only the concepts of rigidness and floppiness to guide our intuitions, the concept is entirely plausible.

The evidence for both solidlike and liquidlike behavior of small clusters comes from two kinds of experiments: one in the laboratory and one on a computer. We can take sequences of electron microscope pictures of clusters of molecules on foreign surfaces, over several hours. Patient observations show that clusters of some substances continually change shape and even drift from place to place, like droplets, while clusters of atoms of other substances maintain their shapes and locations indefinitely, like tiny crystals. No one has yet seen whether the clusters of molecules of a single compound on a surface show both solidlike and liquidlike behavior.

The computer experiments are mathematical simulations of up to several hundred molecules in space. The modeler giving the instructions has great freedom of choice. He or she can choose the kinds of forces the particles exert on one another, the number of particles in each cluster, and the amount of heat energy available to the clusters. The modeler can then watch how the simulated particles move, find where they store energy, and determine which clusters, if any, are stable and capable of growing.

The principal outcome of the computer experiments is this: clusters, even those as small as three particles, can look either like solids or liquids, depending on their temperatures. If the energy of the cluster is low enough, the component particles stay fixed the way atoms do in a conventional rigid molecule. If the energy of the cluster is higher, the atoms remain bound together but form a floppy molecule.

The computer tells us the difference between rigid and floppy structures in two ways. The computer can keep a record of the distance between a particle and its neighbors. If, as the "particles move" in the computer simulation, the distances between neighbors stay within narrow limits, the atoms must be remaining close to their home bases. On the other hand, if particles that were once close together appear later on opposite sides of the cluster, then the cluster must be floppy or liquidlike. This is the more obvious way to infer the amount of floppiness from a computer simulation. The other requires the computer to keep track of where the energy goes if heat is put into the cluster. If the cluster remains forever rigid, then the added heat all goes into raising its temperature. If the cluster can "melt," then at or near the "melting point," the heat goes into melting, just as the heat of a warm room goes into melting the ice in a glass of ice water. Only after all the ice is gone does the water start to warm.

We close by looking at the underlying generalities that relate floppy molecules and clusters with ordinary melting. The essence of such a generalization about molecules is in what it says about the quantum states of the molecules: What are the places where a molecule can store energy; how big are the discrete packages, or quanta, that can be taken up by each of these places; and how many quanta of energy can each contain? If we know the answers to these questions for the solid and liquid forms of a substance, be it a molecule that can be rigid or floppy or a bulk material that can be solid or liquid, we can then predict when one form or the other will be the stable one.

We firmly believe that true transitions between liquid and solid—called phase transitions—are only possible for very large collections or particles. For something composed of only a few particles, according to contemporary theories of phase transitions, there should be ranges of temperature where solidlike and liquidlike structures can coexist and be stable in detectable quantities. This phenomenon, the stable coexistence of solid and liquid over a range of temperature (as distinguished from the *unstable* conditions of supercooled liquids or superheated solids or liquids), is quite foreign to our everyday experience. Ice water has only one temperature, not a range of temperatures. Yet logic and science tell us that such coexistence should be possible; small clusters should have melting ranges, rather than melting points.

We have believed that when water vapor condenses it forms either water droplets or snow crystals but not both; now we may have to revise our ideas of how the condensation process takes place. No one has yet tried to observe this strange property of matter at the microscopic level, but now that we recognize the question, someone probably will. The result will help tell us something about why water vapor turns to rain or snow. □

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Darwin's Middle Road

He avoided both of the two clear paths to scientific discovery

"We began to sail up the narrow strait lamenting," narrates Odysseus.

> For on the one hand lay Scylla, with twelve feet all dangling down; and six necks exceeding long, and on each a hideous head, and therein three rows of teeth set thick and close, full of black death. And on the other mighty Charybdis sucked down the salt sea water. As often as she belched it forth, like a cauldron on a great fire she would seethe up through all her troubled deeps.

Odysseus managed to swerve around Charybdis, but Scylla grabbed six of his finest men and devoured them in his sight, "the most pitiful thing mine eyes have seen of all my travail in searching out the paths of the sea."

False lures and dangers often come in pairs in our legends and metaphors—consider the frying pan and the fire or the devil and the deep blue sea. Prescriptions for avoidance emphasize either a dogged steadiness—the straight and narrow of Christian evangelists—or an averaging between unpleasant alternatives—the golden mean of Aristotle. The idea of steering a course between undesirable extremes emerges as a central prescription for a sensible life.

The nature of scientific creativity is both a perennial topic of discussion and a prime candidate for seeking a golden mean. The two extreme positions have not been directly competing for allegiance of the unwary. They have, rather, replaced each other sequentially, with one now in the ascendancy, the other eclipsed.

The first, inductivism, held that great scientists are primarily great observers and patient accumulators of information. New and significant theory, the inductivists claimed, can only arise from a firm foundation of facts. In this architectural view, each fact is a brick in a structure built without blueprints. Any talk or thought about theory (the completed building) is fatuous and premature before the bricks are set. Inductivism once commanded great prestige within science and even represented an "official" position of sorts, for it touted, however falsely, the utter honesty, complete objectivity, and almost automatic nature of scientific progress toward final and incontrovertible truth.

Yet, as its critics so rightly claimed, inductivism also depicted science as a heartless, almost inhuman discipline offering no legitimate place to quirkiness, intuition, and all the other subjective attributes adhering to our vernacular concept of genius. Great scientists, the critics argued, are distinguished more by their powers of hunch and synthesis than by their skill in experiment or observation. The criticisms are certainly valid and I welcome the dethroning of inductivism during the past thirty years as a necessary prelude to better understanding. While attacking inductivism so strongly, some critics have tried to substitute an alternative, "eureka" view of scientific creativity. (The name refers, of course, to the legendary story of Archimedes running naked through the streets of Syracuse shouting "Eureka" [I have discovered it] when water displaced by his bathing body washed the scales abruptly from his eyes and suggested a method for measuring volumes.) In this eureka view, creativity is an ineffable something, accessible only to persons of genius. It arises like a bolt of lightning, unanticipated, unpredictable, and unanalyzable—and the bolts strike only a few special people. We ordinary mortals must stand in awe and thanks.

I am equally disenchanted by both these opposing extremes. Inductivism reduces genius to dull, rote operations; eurekaism elevates it to an inaccessible status, more in the domain of intrinsic mystery than in a realm where we might understand and learn from it. Might we not marry the good features of each view and abandon both the elitism of eureka and the pedestrian qualities of inductivism.

In the hagiography of science, a few men hold such high positions that all arguments about creativity must apply to them if they are to have any validity. Charles Darwin, as the principal saint of evolutionary biology, has therefore been presented both as an inductivist and as a primary example of eureka. I will attempt to show that these interpretations are equally inadequate and that recent scholarship on Darwin's own odyssey toward the theory of natural selection supports an intermediate position.

So great was the prestige of inductivism in his own day that Darwin himself fell under its sway and, as an old man, falsely depicted his youthful accomplishments in its light. In an autobiography, which was written as a lesson in morality for his children and not intended for publication, he penned some famous lines that misled historians for nearly a hundred years. Describing his path to the theory of natural selection, he claimed: "I worked on true Baconian principles, and without any theory collected facts on a wholesale scale."

The inductivist interpretation focuses on Darwin's five years aboard the *Beagle* and views his transition from a student for the ministry to the nemesis of preachers as a result of his keen powers of observation applied to the whole world. Thus, the traditional story goes, Darwin's eyes opened wider and wider as he saw, in sequence, the bones of giant South American fossil mammals, the turtles and finches of the Galapagos, and the marsupial fauna of Australia. The truth

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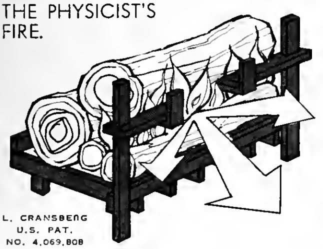

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of evolution and its mechanism of natural selection crept up gradually upon him as he sifted facts in a sieve of utter objectivity.

The inadequacies of this tale are best illustrated by the falsity of its conventional premier example—the so-called Darwin's finches of the Galápagos. We now know that although these birds share a recent and common ancestry on the South American mainland, they have radiated into an impressive array of species on the outlying Galápagos. Few terrestrial species manage to cross the wide oceanic barrier between South America and the Galápagos. The fortunate migrants often find an island devoid of the competitors that limited their opportunities on the crowded mainland. Hence, the finches evolved into roles normally occupied by other birds and developed their famous set of adaptations for feeding—seed crushing, insect eating, even grasping and manipulating a cactus needle to dislodge insects from plants. Isolation, both from the mainland and among the islands themselves, provided an opportunity for separation, independent adaptation, and speciation.

According to the traditional view, Darwin discovered these finches, correctly inferred their history, and wrote the famous lines in his notebook: "If there is the slightest foundation for these remarks the zoology of Archipelagoes will be worth examining; for such facts would undermine the stability of Species." But, as with so many heroic tales, from Washington's cherry tree to the piety of Crusaders, hope rather than truth motivates the common reading. Darwin found the finches to be sure. But at the time he did not recognize them as variants of a common stock. In fact, he didn't even record the island of discovery for many of them; some of his labels just read "Galápagos Islands." So much for his immediate recognition of the role of isolation in the formation of new species. He reconstructed the evolutionary tale only after his return to London, when a British Museum ornithologist correctly identified all the birds as finches.

The famous quotation from his notebook refers to Galápagos tortoises and to the claim of native inhabitants that they can "at once pronounce from which Island any Tortoise may have been brought" from subtle differences in size and shape of body and scales. This is a statement of different, and much reduced, order from the traditional tale of finches. For the finches are true and separate species—a living example of evolution. The subtle differences among tortoises represent minor geographical variation within a single species. It is a jump in reasoning, albeit a valid one as we now know, to argue that such small differences can be amplified to produce a new species. All creationists, after all, acknowledged geographical variation (consider human races), but argued that the differences could not proceed beyond the rigid limits of a created archetype.

I don't wish to downplay the pivotal influence of the *Beagle* voyage on Darwin's career. It gave him space, freedom, and time to think in his favored mode of independent self-stimulation. (His ambivalence toward university life and his middling performance there by conventional standards reflected his unhappiness with a curriculum of received wisdom.) He writes from South America in 1834: "I have not one clear idea about cleavage, stratification, lines of upheaval. I have no books, which tell me much and what they do I cannot apply to what I see. In consequence I draw my own conclusions, and most gloriously ridiculous ones they are."

The rocks and plants and animals that he saw did provoke him to the crucial attitude of doubt—midwife of all creativity. Sydney, Australia, 1836. Darwin wonders why a rational God would create so many marsupials in Australia since nothing about its climate or geography suggests any superiority for pouches: "I had been lying on a sunny bank and was reflecting on the strange character of the animals of this country as compared to the rest of the World. An unbeliever in everything beyond his own reason might exclaim, 'Surely two distinct Creators must have been at work.'"

Nonetheless, Darwin returned to London without an evolutionary theory. He suspected the truth of evolution but had no mechanism to explain it. Natural selection did not arise from any direct reading of facts during the *Beagle*'s voyage, but from two subsequent years of thought and struggle as reflected in a series of remarkable notebooks that have been unearthed and published during the past twenty years. In these notebooks we see Darwin testing and abandoning a number of theories, pursuing a multitude of false leads—so much for his later claim about recording facts with an empty mind. He read philosophers, poets, and economists, always searching for

meaning and insight—so much for the notion that natural selection arose inductively from the *Beagle*'s facts. Later he labeled one notebook as "full of metaphysics on morals."

Yet if this tortuous path belies the Scylla of inductivism, it has engendered an equally simplistic myth, the Charybdis of eureka. In his maddeningly misleading autobiography, Darwin does record a eureka and suggests that natural selection struck him as a sudden, serendipitous flash after more than a year of groping frustration:

> In October 1838, that is, fifteen months after I had begun my systematic inquiry, I happened to read for amusement Malthus on Population, and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favorable variations would tend to be preserved, and unfavorable ones to be destroyed. The result of this would be the formation of new species. Here, then, I had at last got a theory by which to work.

Yet, again, the notebooks belie Darwin's later recollections—in this case by their utter failure to record, at the time it happened, any special exultation over his Malthusian insight. He inscribes it as a fairly short and sober entry without a single exclamation point, although he habitually used two or three in moments of excitement. He did not drop everything and reinterpret a confusing world in its light. On the very next day, he wrote an even longer passage on the sexual curiosity of primates.

The theory of natural selection arose neither as a workmanlike induction from nature's facts nor as a mysterious bolt from Darwin's subconscious, triggered by an accidental reading of Malthus. It emerged instead as the result of a conscious and productive search, proceeding in a ramifying but ordered manner, and utilizing both the facts of natural history and an astonishingly broad range of insights from disparate disciplines far from his own. Darwin trod the middle path between inductivism and eurekaism. His genius is neither pedestrian nor inaccessible.

Darwinian scholarship has exploded since the centennial of the *Origin* in 1959. The publication of Darwin's notebooks and the attention devoted by several scholars to the two crucial years between the *Beagle*'s docking and the demoted Malthusian insight has clinched the argument for a "middle path" theory of Darwin's crea-

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tivity. Two particularly important works focus on the broadest and narrowest scales.

Howard E. Gruber's masterful intellectual and psychological biography of this phase in Darwin's life (*Darwin on Man*, E.P. Dutton, 1974) traces all the false leads and turning points in Darwin's search. Gruber shows that Darwin was continually proposing, testing, and abandoning hypotheses, and that he never simply collected facts in a blind way. He began with a fanciful theory involving the idea that new species arise with a pre-fixed life span and worked his way gradually, if fitfully, toward an idea of extinction by competition in a world of struggle. He recorded no exultation upon reading Malthus, because the jigsaw puzzle was only missing a piece or two at the time.

Silvan S. Schweber has reconstructed, in detail as minute as the record will allow, Darwin's activities during the few weeks before Malthus ("The Origin of the *Origin* Revisited," *Journal of the History of Biology*, vol. 10). He argues that the final pieces arose not from new facts in natural history, but from Darwin's intellectual wanderings in distant fields. In particular, Darwin read a long review of social scientist and philosopher Auguste Comte's most famous work, the *Cours de philosophie positive*. He was particularly struck by Comte's insistence that a proper theory be predictive and capable of making quantitative statements.

He then turned to Dugald Stewart's *On the Life and Writing of Adam Smith*, and imbibed the basic belief of the Scottish economists that theories of overall social structure must begin by analyzing the unconstrained actions of individuals. (Natural selection is, above all, a theory about the struggle of individual organisms for success in reproduction.)

Then, searching for quantification, he read a lengthy analysis of work by the most famous statistician of his time—the Belgian Adolphe Quetelet. In the review of Quetelet, he found, among other things, a forceful statement of Malthus's quantitative claim—that population would grow geometrically and food supplies only arithmetically, thus guaranteeing an intense struggle for existence. In fact, Darwin had read the Malthusian statement several times before; but only now was he prepared to appreciate its significance. Thus, he did not turn to Malthus by accident, and he already knew what it contained. His "amusement," we must assume, consisted only in a desire to read in its original formulation the familiar statement that had so impressed him in Quetelet's secondary account.

In reading Schweber's detailed account of the moments preceding Darwin's formulation of the theory of natural selection, I was particularly struck by the absence of deciding influence from his own field of biology. The immediate precipitators were a social scientist, an economist, and a statistician. If genius has any common denominator, I would advocate breadth of interest and the ability to construct fruitful analogies between fields.

In fact, I believe that the theory of natural selection should be viewed as an extended analogy—whether conscious or unconscious on Darwin's part I do not know—to the laissez-faire economics of Adam Smith. The essence of Smith's argument is a paradox of sorts: if you want an ordered economy providing maximal benefits to all, then let individuals compete and struggle for their own advantages. The result, after eliminating the inefficient and appropriate sorting of the rest, will be a stable, harmonious polity. Apparent order arises naturally from the struggle among individuals, not from predestined principles or higher control.

We know that Darwin's uniqueness does not reside in his support for the idea of evolution—scores of scientists had preceded him in this. His special contribution rests upon his documentation and upon the novel character of his theory about how evolution operates. Previous evolutionists had proposed unworkable schemes based on internal perfecting tendencies and inherent directions. Darwin advocated a natural and testable theory based on immediate interaction among individuals (his opponents considered it heartlessly mechanistic). The theory of natural selection is a creative transfer to biology of Adam Smith's basic argument for a rational economy: the balance and order of nature does not arise from a higher, external (divine) control or from the existence of laws operating directly upon the whole, but from struggle among individuals for their own benefits (in modern terms, for the transmission of their genes to future generations through differential success in reproduction).

Many people are distressed to hear such an argument. Does it not compromise the integrity of science if some of its primary conclusions originate by analogy with contemporary politics and culture rather than from data of the discipline itself? In a famous letter to Engels, Karl Marx identified the similarities between natural selection and the English social scene:

It is remarkable how Darwin recognizes among beasts and plants his English society with its division of labor, competition, opening up of new markets, "invention," and the Malthusian "struggle for existence." It is Hobbes' *bellum omnium contra omnes* (the war of all against all).

Yet Marx was a great admirer of Darwin—and in this apparent paradox lies resolution. For reasons involving all the themes I have emphasized here—that inductivism is inadequate, that creativity demands breadth, and that analogy is a profound source of insight—great thinkers cannot be divorced from their social background.

But the *source* of an idea is one thing; its *truth* or *fruitfulness* is another. The psychology and utility of discovery are very different subjects indeed. Darwin may have cribbed the idea of natural selection from economics, but it may still be right. As the German socialist Karl Kautsky wrote in 1902: "The fact that an idea emanates from a particular class, or accords with their interests, of course proves nothing as to its truth or falsity." In this ironic case, Adam Smith's system of laissez-faire does not work in his own domain of economics, for it leads to oligopoly and revolution, rather than to order and harmony. Struggle among individuals does, however, seem to be the law of nature.

Many people use such arguments about social context to ascribe great insights primarily to the indefinable phenomenon of good luck. Thus, Darwin was lucky to be born rich, lucky to be on the *Beagle*, lucky to live amidst the ideas of his age, lucky to trip over Parson Malthus—essentially little more than a man in the right place at the right time. Yet, when we read of his personal struggle to understand, the breadth of his concerns and study, and the directedness of his search for a mechanism of evolution, we can understand why Pasteur made his famous quip that fortune favors the prepared mind.

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Three Spines on a Stickleback

With a little help from a spiny defense, and staunch parental care, a small fish has colonized much of the coastal waters of the Northern Hemisphere

by Fred Hartmann

photographs by Dwight R. Kuhn

With armorlike spines protruding from its back, a threespine stickleback appears menacing. But that is mainly in the eye of the human observer. The less than dramatic fact is that the spines are a defensive adaptation for a fish that averages a mere two inches or less in length. This adaptation, so contributory to how the fish looks, is often effective in its intended role. Against piscivorous fish, the most significant predators of sticklebacks, the spines are a definite aid in survival. If a choice is available, most predatory fish, such as pike, perch, trout, salmon, and sculpin, tend to take other prey species in preference to sticklebacks. A stickleback can lock its spines in place, so that they cannot be compressed in the mouth of the predator. The latter can make a meal of a stickleback, but it would be an unpleasant experience and a lesson that is learned. The effectiveness of the spiny defense declines as the size of the predatory fish increases, probably because the gape of larger fish makes it easier to accommodate and swallow sticklebacks. These small fish are also regularly taken by such fish-eating birds as diving ducks, herons, black-headed gulls, and terns, and by such mammals as the mink and European otter. And young sticklebacks are taken by the larvae of some aquatic insects.

There are other important sources of mortality in sticklebacks. Sticklebacks are often hosts to a variety of parasites that can severely affect a localized population; in one such population, more than fifty species of ecto- and endo-parasites were discovered infesting the fish. Sticklebacks also have a propensity for eating the eggs of their own kind. And other fish species also find stickleback eggs a delicacy.

Threespine sticklebacks have elongate, laterally compressed bodies. All adults are variably colored above—silvery green, greenish brown, and olive—interspersed in some individuals and populations with dark, mottled markings. Their sides are paler, and the belly silver. During the breeding season, males become brilliant red on their belly and flanks and develop bright blue eye rings. At this time, females have pink tints on their throats and bellies.

The variation in color, accompanied by a range in some of their bodily features, can be related, in part, to their wide geographical distribution. The threespine stickleback, *Gasterosteus aculeatus*, has an almost circumpolar distribution in the Northern Hemisphere. In North America, the fish is found from Chesapeake Bay, north to the coastal waters of New England, along the full extent of the Saint Lawrence River into Lake Erie, and throughout southern Greenland and the shores of Hudson Bay. A gap in the distribution exists in the Canadian Arctic west of Hudson Bay; the species reappears in the Bering Strait and occurs southward in coastal drainages to Japan on one side of the Pacific and to Baja California on the other. In Europe, the species is found in the arctic waters of the western Soviet Union, Norway, Iceland, southward to Spain, and in the Mediterranean and Black seas. Threespine sticklebacks inhabit offshore waters, brackish water, and fresh water, but all populations spawn in fresh water. The fish generally do not venture far from shore, be it in the ocean or sea, river or lake.

The reproductive biology of the threespine stickleback has been intensively studied because of its complex behavior, its variability, and the ease with which it breeds in captivity (the photographs accompanying this article were taken in an aquarium). Consequently, much of what is known about this species has been learned in the laboratory, with problematical application to the natural state. In essence, the threespine stickleback breeds in spring and summer, the timing probably dependent on geographical location and the temperature and salinity of the water. Other factors may also be involved. Outside of the breeding season, both sexes tend to school up to a mile from shore. With the onset of breeding, the males break away from these congregations and move toward shallow shore waters to establish territories, usually over a sandy substrate, in tidal flats, backwaters, and streams. The male then builds a nest of plant matter and sand grains, glues it together with a mucilaginous secretion from his kidneys, and completes it with the construction of entrance and exit tunnels. The male defends his territory from intruding stickleback males and other species of fish.

Courtship begins when gravid females enter the male's territory. The male approaches his prospective mate in a series of zigzag movements. She assumes a "head-up" posture and moves toward her suitor. After some further preliminaries by the male, consisting of a return to the nest and the performance of such behaviors as "fanning" and adding more glue to the nuptial chamber, he reapproaches the female, then swims directly back to the nest. If the female follows, he points his snout toward the entrance tunnel of the nest. The female then pushes her

Arranging bits of plants that he has carried to the site, a male stickleback begins to make a nest.

Many trips are necessary before the male has gathered enough plant material to glue into a nest.

The male completes the nest by spitting sand over it. The entrance and exit holes are left clear.

Head pointed upward, back arched, a female (left) signals the courting male that she is ready to spawn.

way into the nest as far as she can go. Her mate gently butts her around the anal region, and when she is snugly within the tight-fitting nest, he begins to quiver. She then raises her tail and lays a batch of eggs. After the female leaves the nest via the exit tunnel, the male emits his sperm over the eggs. If the spent female is in the vicinity after he has completed his share of the mating, he quickly sends her on her way.

The male now begins his role as parent. He ventilates the eggs by fanning water through the nest, and when they hatch, he clears the nest chamber of vegetation. For the next few days he retrieves fry that have wandered from the nest site. But as the young become more active and agile, they disperse from the nest area. During this parental phase, the male becomes darker, which makes him less conspicuous to predators.

After the dispersal of his young, the male often builds another nest, usually within a few days. In captivity, males have gone through the reproductive cycle five or more times, but whether this also occurs in the wild is not yet known. Based on observations of captive fish, females are thought to produce several clutches of eggs if they are large-sized and sufficient food is available. The parental care exhibited by the male, and the production of more than one clutch of eggs in a breeding season, help insure that a high number of offspring survive for the next generation of threespine sticklebacks. □

young hatch with large yolk ... and generally remain in the nest for a period of two days.

Sticking his head into the entrance hole, the male indicates to his mate that she should enter the nest.

With his mate inside, the male prods her protruding tail, stimulating her to lay eggs.

Finished laying, the female leaves the nest. The male will now enter and fertilize the 50 to 100 eggs.

The Weevil and the Wasp

An alien weevil has marched across the alfalfa fields of the west, with its natural enemy, a wasp, in close pursuit

by William H. Jordan, Jr.

Each spring in California, two species of beetles attack the early alfalfa crop. From the northern part of the state, where the alfalfa weevil lives in the high volcanic valleys, to central and southern California, where the Egyptian alfalfa weevil occupies the inland valleys, the coastal plains, and the southeastern deserts, these beetles and their larvae cost farmers millions of dollars each year, making them the state's worst alfalfa pest.

But the damage is not uniform throughout this range, and in certain areas, such as the Salinas Valley and the San Francisco Bay region, the weevils do not devastate the alfalfa crop. Why are these insects a pestilence in one region but not another? The answer to this intriguing question involves a small wasp and its intricate relationship with the weevils. The story begins with appearances and histories and ends with seasons, climates, and life cycles.

The two weevils are nearly identical; in fact, individuals cannot be separated as species on physical characters alone. Small, compact beetles, six to eight millimeters long, these weevils range from tan to gray black; a darker stripe runs down the back. They have a typical weevil snout—a long tube with two small antennae, reminiscent of spectacles, perched near the tip, and two small mandibles set in the end. The snout is a practical device for masticating alfalfa and drilling neat holes in the hollow stems so the females can deposit clusters of eggs inside.

The larvae grow from slivers one to two millimeters long when first hatched to succulent green grubs ten to thirteen millimeters long when fully developed, with a yellow green stripe down the back. These larvae, not the adults, damage the alfalfa crops because they eat voraciously, not only to grow as fast as possible but also to grow layers of fat in preparation for the metabolic ordeal of metamorphosis and the stress of hibernation; as adults, they eat only to maintain their strength and produce eggs or sperm.

Sometimes larvae by the hundreds of millions infest a single field, so by culling a spray of alfalfa, you can collect 50 to 100 of them in your cupped hand. A dog ambling a few feet into an infested field will collect hundreds of the writhing grubs in its fur. The larvae can devour a crop in one week. On Monday the field may be a lush carpet one to two feet high; on the next Sunday it may be a patch of whitish gray straw with leaves stripped to their veins and dangling from stems, like the skeletons of little fish.

Fortunately, a parasitic wasp, *Bathyplectes curculionis*, attacks the larvae of these weevils, or they would ravage alfalfa even more severely. A member of the Ichneumonidae family, these shiny black insects are about one-third inch long and have yellow abdomens. Males and females look alike, except that the males taper to a blunt end while females have a saberlike ovipositor that curves backward and upward. With this device, they pierce the weevil's larvae and lay an egg inside each victim, so a larval wasp develops inside. When its growth ends, it kills the weevil grub, its host and victim. Under the right conditions, populations of these parasites can drastically reduce weevil numbers.

All three insects—the alfalfa weevil, the Egyptian alfalfa weevil, and the parasitic wasp—are not native to North America. The wasp comes from middle Europe, and as far as we can tell, the weevils come from Europe and from northern Africa.

The alfalfa weevil, *Hypera postica*, arrived in 1904, apparently in the baggage of European immigrants, and colonized a field of altalfa on the east side of Salt Lake, Utah. As they multiplied, the weevils damaged crops and spread rapidly to neighboring fields. For a few years they remained in Utah, a state barricaded by mountains, but in 1911 they appeared in Idaho; then, in quick succession, in Wyoming, Colorado, and Oregon. Nevada joined the ranks of weevil states in 1920, Nebraska in 1928, and finally California in 1929. But an interesting thing happened to the weevils on their way through California: they encountered some difficult climates. While dispersing through the

An alfalfa weevil begins a meal on a budding alfalfa plant in California. The adults do not cause as much crop damage as the larvae because their food requirements are much lower.

William H. Jordan Jr

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A cluster of alfalfa weevil eggs can be seen in a section of an alfalfa stem that has been cut open. The deposition hole made by the adult female is visible on the outer half of the stem.

other states, by flying with the wind or transported in hay, they traveled about ten to twenty miles per year and seriously damaged crops every year after establishing themselves. Entering California in the northeast corner, a region east of the Sierra Nevada and similar to the Salt Lake Valley in altitude, climate, flora, and fauna, they quickly affected agriculture. But when they crossed the Sierras and entered the great San Joaquin Valley, they had to cope with a long, hot summer. Here their pattern changed. They would damage a field for a year or two, then not bother it for several years; they would devastate one field, yet leave its neighbor untouched. And they stopped moving south. Although there were no physical barriers to their further movement—the valley, lush with alfalfa, stretched for another 200 miles—they colonized no farther. They reached Los Banos, roughly at the San Joaquin's midpoint, and just stopped there. Intense summer heat seemed to be the only explanation.

At the same time (the early 1930s) the weevils were also colonizing the coastal valleys around San Francisco Bay and Salinas. In these moderate, steady climates, ranchers suddenly noticed a new insect in their alfalfa ecosystems.

By the 1940s the alfalfa weevil had reached its adaptive limits. It thrived in the northeastern mountains and in the midcoastal valleys, but existed only tenuously in the San Joaquin Valley. But in 1939 another species, the Egyptian alfalfa weevil, *Hypera brunneipennis*, arrived at Yuma, Arizona, on date palms imported from Egypt. At first it did not attack alfalfa, feeding on wild clover instead. Its tastes soon changed, however, and multitudes appeared in the Imperial Valley's rich farmland—a desert basin at the mouth of the Colorado River that modern irrigation had transformed into an agricultural oasis.

This weevil's ability to exploit the southeastern desert was an important development in the expansion of its range. Temperatures in the desert reach 125°F in summer, and an estimated one-third to one-half of its human population migrates to the cooler coast, returning in the fall when the temperature drops down to the upper 90s. If this weevil arrived in the San Joaquin Valley, it would probably thrive in the more moderate environment.

Spreading west to the San Diego area in 1950, then north to San Luis Obispo in 1956, *H. brunneipennis* moved relentlessly. It left a clear trail—one year an unblemished crop would develop; the second year it would sport some perforated leaves; the third, it would be riddled. And there was no doubt as to what species of weevil was at work: only the Egyptian could survive the scorching heat.

In 1963 weevils again started to overrun crops in the Salinas Valley; the same thing happened in 1965 in the Sacramento Valley (the northern arm of the great central valley). Many researchers assumed that vagaries of local climate had stimulated these outbreaks, but others wondered why the alfalfa weevil, *H. postica*, should suddenly flare up along the coast after the parasitic wasp had controlled it for more than twenty years or how it had adjusted so abruptly to the summer heat that had thwarted it for thirty-five years.

In 1966 the truth came out: weevils were discovered near Porterville in the southern San Joaquin Valley. Since only the Egyptian weevil could survive there, that population was probably *H. brunneipennis*—which would help explain the strange outbreaks. Even more ominous, these resurging populations might be *H. postica-brunneipennis* hybrids—creatures with the combined strengths of both parent species.

The Egyptian alfalfa weevil is more difficult for the parasitic wasp to control than *H. postica*, because its larvae physiologically fight the parasites. Most individuals have blood cells that adhere to the wasp's eggs and smother them with a thick, cellular blanket. The wasp, in turn, can overcome this defense by laying several eggs in the same host. And in the coastal valleys where the wasps are numerous enough to inject several eggs into most of the weevil larvae, they can still hold weevil populations (whatever the species or hybrid) below damaging levels if farmers do not interfere by the careless use of pesticides. In time the parasite evolves a chemical coating that prevents the blood cells from adhering to its eggs, which further increases the effectiveness of the wasps.

The wasp was imported with the best intentions and loftiest hopes. When the alfalfa weevil began turning alfalfa to crops of straw in the early 1900s, government agencies grew deeply concerned about the problem and decided to try biological control. The idea was to import parasites and predators from the pest's homeland—middle Europe—where the weevil was not an agricultural problem, most probably because its natural enemies held it in check. Since the U.S. Department of Agriculture already had entomologists in Italy, France, and Switzerland to collect parasites of other agricultural pests, and since it was agreed that the alfalfa weevil originated somewhere in middle

Europe, it would be simple to import the weevil's predators and parasites. The entomologists quickly discovered a parasite, *B. curculionis*, and sent home several thousand of its cocoons. From 1911 to 1912, the USDA set out 1,554 near Salt Lake.

The wasps quickly colonized the area and, proving to be good travelers, began to follow the weevils. They moved even faster than their hosts had moved, sometimes spreading thirty to forty miles per year, until they caught up with the advancing weevils. After that, they kept up with the weevils as they expanded their range. On the few occasions that the weevils hurdled geologic barriers—crossing the Sierra Nevada to California in the case of the alfalfa weevil and colonizing the southwestern deserts in the case of the Egyptian species—the USDA quickly sent wasps in from Utah to save time and to prevent the weevils from multiplying unchecked.

The results were not a smashing victory. In the colder western states, such as Utah and Wyoming, the wasp reduced the weevil populations in some years but not in others. In the deserts the parasite never seemed to have much effect. But in the San Francisco Bay region and in the Salinas Valley, the wasp dominated the weevil. In fact, from about 1940 until the early 1960s, it was difficult to find any weevils at all.

An important reason for these results is that biological control is a populational process that occurs over a span of time and involves the entire life cycle. In the case of the weevils, both species begin their life cycles early in the spring, as soon as temperatures permit the adults to emerge, feed, copulate, and lay eggs. Hatching in several days to a week, the tiny larvae crawl through the oviposition holes and onto a plant's outer surface. They climb upward toward the light and end up on the terminal buds where they ensconse themselves between the tightly folded leaves. Soon they molt to the second instar and venture out to more exposed parts of the buds. As third instars they cease hiding and feed on open leaves. As final, fourth instars the larvae often chew holes in a leaf, curl their bodies through, and grip the surface when feeding. After three to four or more weeks, engorged and corpulent, the now mature larvae either remain on the plant (*H. brunneipennis*) or crawl down to the chaff on the ground (*H. postica*). Wherever they are, they spin loose, white cocoons, then pupate and metamorphose into adults.

Ten days to several weeks later, the new adults begin to emerge. They immediately crawl to nearby foliage and start eating. After two to four weeks of continual feeding, during which they lay down stores of fat, they seek suitable sites to hibernate, or diapause. *H. brunneipennis* finds trees, buildings, and other prominent objects; *H. postica* finds debris on the ground under the alfalfa or weeds around the field. In this dormant condition, both species pass through the heat of summer and early fall.

Diapause ends later in the fall, but the weevils, now mature, remain quiescent. They can move about, eat, mate, and develop eggs should the weather permit; yet, they can also withstand normal winter cold in a harmless stupor. And so, they wait out the winter to reproduce in the first warmth of spring. Both weevil species have one generation per year. The wasps also emerge from diapause in the early spring, shortly after the weevils. They copulate as soon as male finds female, then the fertilized females hurry off in search of victims for their eggs.

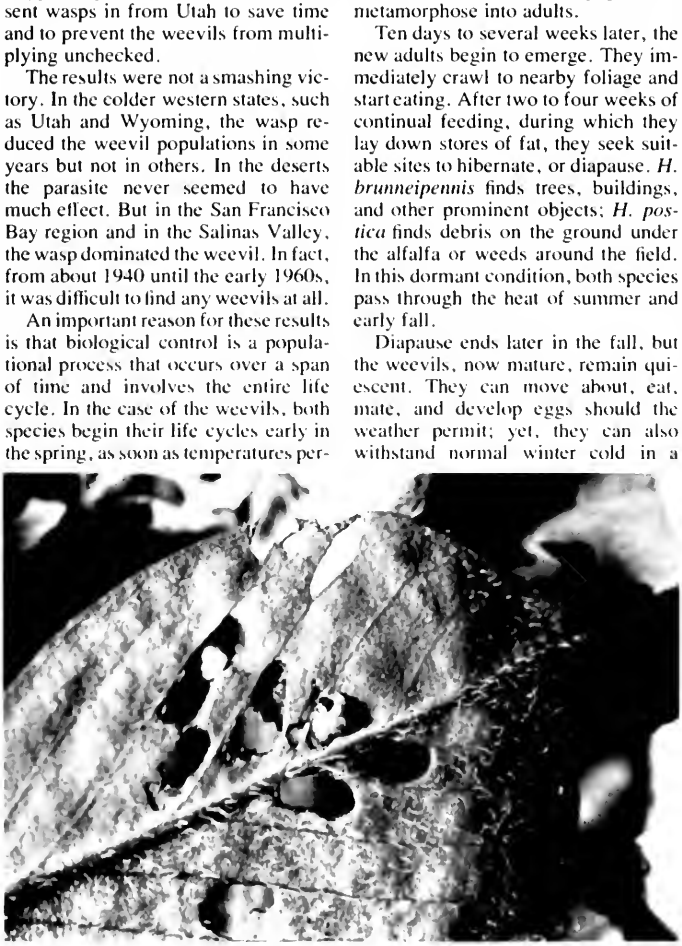
At this point the newly hatched weevil larvae lie deep in the buds, so the wasps must probe with their piercing ovipositor to locate and plant eggs in them. This first-hatched flight of adult wasps begets the first brood of parasitic larvae.

The young parasites develop inside their weevil hosts, feasting on fluids and tissues but avoiding the vital organs. When the parasitized weevil grubs have finished growing and have spun their cocoons, the wasp larvae kill their victims, consume their remaining tissues, crawl from the shriveled skins, and spin their cocoons inside the weevil cocoons.

An interesting development then occurs: the parasites either mature and hatch or they remain larvae and diapause. Those that hatch spend several weeks metamorphosing and then emerge as the second flight of adults—the F_2, or nondiapausing, generation—and beget the second brood of parasite larvae. Those that diapause, whether from the first or second brood, pass over the summer, fall, and winter to emerge the following spring and start the cycles of the next year.

Wasps of the first brood—the offspring of adults of the first flight—generally develop to adulthood; they become the second flight of parasitic wasps. In most of the inland regions, possibly 60 to 80 percent go on to adulthood and 20 to 40 percent go dormant. The second brood reverses this tendency, and almost all the larval wasps suspend development until the next year.

Perhaps the most important feature of this life cycle is that the wasp has two generations per year. Wherever it



William H. Jordan Jr.

Curling through a feeding hole on an alfalfa leaf, a fourth instar weevil larva creates an earring effect. After three to four weeks of gorging, the larva will spin its loose, white cocoon.

lives in California it exhibits the same two-brooded pattern. Since wasps emerge from diapause along with the weevils in the early spring and since wasp larvae develop twice as fast as weevil larvae, this two-brooded pattern of the parasite appears to be genetically determined.

But development and diapause are also influenced by temperature and climate. And temperature and climate hold the final key to understanding why the wasp controls the weevils only in particular regions.

Because insects are ectothermic (drawing most of their body heat from the outside environment), the weevils and their parasites must wait until the weather is warm enough to support activity. Both the weevils and the wasp need temperatures of about 50°F before they can grow; conversely, neither insect can tolerate temperatures much above 90°F, and even temperatures higher than 86°F begin to irritate them. Diapausing, they bow out of summer activities.

Dormancy is not just a method of escape, however. It is also a device for synchronizing with the environment, since the onset and the offturn are adjusted to the climates of each region. Day length, temperature, diet, and other cues trigger diapause; exposure to a certain amount of cold, and sometimes day length, end it. (Ironically, even though the phenomenon of diapause is necessary for many insects to survive periods of cold, a certain amount of cold is also necessary for the insect to break out of its diapause.) Each climate therefore modifies the basic life cycles. This modification is known as phenology—the life cycle as altered by environment.

The upshot of their phenologies is that the two populations appear at just the right time of year for finding favorable conditions: in the weevils' case, correct temperatures and fresh alfalfa; in the parasite's, appropriate temperatures and weevil larvae. Climate, therefore, holds enormous power for altering the life cycles of any insect. A climate with short springs and summers allows activity briefly each year; a climate with long, moderate springs and summers permits a long period of activity. In the case of the weevils and their parasites, this influence is critical to agriculture. The Salinas Valley and the McArthur valley are fine examples.

Opening on the sea, the Salinas Valley is cool and salubrious during the spring and summer. Each morning, breezes flowing in from the cold, offshore water carry clouds over the farmland and hold the temperature at an average high of about 70°F. In these gentle conditions the weevils and wasps develop at a moderate, constant rate, which changes the growth of the generations and, ultimately, the relationship between host and parasite.

The weevils spread their activity over four to four and a half months, the adults laying eggs at a leisurely pace all through the spring. This creates a brood of weevil larvae that is somewhat less dense and much slower in maturing than the weevil broods that play out their roles over a few months in the mountains or the inland valleys.

The Salinas Valley wasps also extend their activities. The first flight hatches from January through April; the second flight starts sometime in mid-March and continues until mid-June. This drawing out of the adult generations is a crucial event because it literally closes a "generation gap." Wasps emerge from diapause over such a prolonged period that before the emergence has ended, nondiapausing wasps—the offspring of diapaused wasps emerging earlier in the season—are already hatching. The generations overlap.

This overlap is the key to natural control: the parasites encounter the peak—the densest population level—of the weevils' brood. In most other areas this does not occur. And not only do the wasps of the coastal valleys encounter the peak population of weevil larvae, but living under cooler, more stable conditions, they actually search at a slower pace. They live longer than their inland relatives and probably parasitize the weevil population more thoroughly.

The moderate climate boosts parasitism in another way. By lowering the proportion of wasps in diapause, the coastal conditions allow the majority of Salinas wasps to mature and hatch during the season, with only 10 to 20 percent of the first generation and 40 to 50 percent of the second passing into dormancy. (A third generation arises in this region, but it finds few weevil larvae and subsides without begetting a large fourth generation; and even though weevil and parasite reproduce at low levels for the rest of the year, the one- and two-brooded life cycles persist as the basic pattern.) Released from a need to diapause, many more of the wasp population can devote their energies to parasitizing weevils and multiplying into denser populations. In this valley, then, the ultimate outcome is biological control, the weevils held below damaging levels.

The McArthur area brings about a wholly different outcome. A broad, mountain valley, four to five thousand feet above sea level, the area does not get warm enough for activity until the end of April; then spring arrives with a rush and summer quickly follows. By the middle of June, temperatures often exceed 105°F, but the weevils, along with their parasites, are safe in their diapause. For these insects the year lasts only about one and a half months.

The fast-rising temperatures and quickly passing season affect everything. With time limited, the entire weevil population emerges over a short period. They eat, mate, and lay eggs in great haste, exhausting themselves within three to five weeks. Since the eggs are laid within a month of each other, the larvae hatch roughly within a month of each other, which compresses them into short-term, extremely dense populations.

The first wasp flight also hatches over a short period, and in the warm and frequently hot days, the wasps scurry over the foliage in search of weevil larvae. And because they die after this short period of intense activity, they leave a true generation gap between their own demise and the arrival of their offspring.

From the farmer's point of view, nothing could be worse. The generation gap falls just when the weevil larvae reach their densest populations, and the large majority escape parasitism. By the time the second flight of wasps start to emerge, many of the weevils have pupated and are safe in their cocoons.

So the short springs and hot summers of the mountains and the inland valleys squeeze the broods of wasps and weevils into brief peaks of existence. Under such restrictions the wasps encounter only a fraction of the weevil population and cannot control

Aerial spraying with insecticides is a control technique used on some alfalfa fields heavily infested with weevils. The introduction of more species of parasitic wasps offers hope for biological control.

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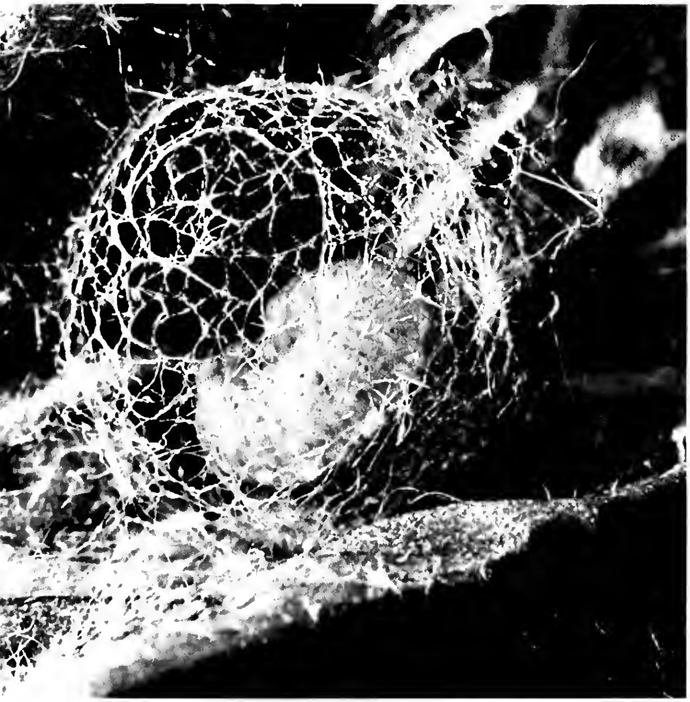

A weevil larva rests between bouts of spinning the cocoon in which it will metamorphose into an adult. Emergence takes place ten days to several weeks after the cocoon is completed, depending on temperature.

it. On the other hand, the long, cool, coastal season relaxes the life cycles, so the generations spread out, the parasite broods and flights overlapping broadly. Under this maritime influence, the generation gap disappears, the parasites can encounter most of the weevil's larvae, and the wasp can control the weevil.

This parasite–host relationship may hold for both weevil species since evidence exists that the Salinas populations have hybridized. In fact, they seem to be more like Egyptian than European weevils in their ability to encap[illegible] the eggs of *B. curculionis*. Yet [illegible] parasites still maintain fair con[illegible] often than not, they hold the [illegible] under the threshold of economic damage.

The future is promising for several reasons. One is that *B. curculionis* gradually evolves resistance to the weevil's defense. The wasps develop a coating substance that prevents the blood cells of the weevils' larvae from encapsulating their eggs. This can only improve their performance as agents of natural control.

Another reason for hope is that the U.S. Department of Agriculture and the University of California have released other parasites. One in particular has excited interest: *B. anuras*, a close relative of *B. curculionis*, which has complete immunity to egg encapsulation and which emerges later in the spring—between the two flights of its cousin and squarely in the middle of the weevil brood. Together the two species may remove the weevils from their pest status. □

Laying an egg, a wasp inserts her ovipositor into a weevil grub. After hatching, the wasp larva will feed on its host but avoid vital organs. The host is killed when the wasp larva has finished growing.

William H. Jordan, Jr

On Keeping Things Up in the Air

The art of juggling has challenged amateurs and professionals since ancient times

by Marcello Truzzi

Juggling, the continuous tossing and catching of objects in the air, is an excellent example of man's extraordinary capacity for play. Some other animals, such as the seal, have been trained to balance objects, but true juggling seems beyond the abilities of even the other higher primates (despite occasional circus posters that falsely picture chimpanzees juggling). That juggling is unique to man should not be surprising since it involves not only remarkable use of the hands but also complex spatial perception and cognitive skills.

The art of juggling has been widely reported among the world's cultures, and some ethnographic descriptions suggest considerable proficiency. John B. Stair, in his 1897 work *Old Samoa; or, Flotsam and Jetsam from the Pacific Ocean*, related: "*O Fuanga* consisted in throwing up a number of oranges into the air, six, seven, or eight, and the object was to keep the whole number in motion at once, as the Chinese jugglers do their balls." And in a 1901 study, *Burma*, Max and Bertha Ferrars wrote:

> A good player [of *chinlon*, a game] will send the ball into the air again and again with decreasing force till he allows it to alight in the hollow of his shoulder. Thence he lets it roll down the back of the arm and jerks it off at the elbow to catch it on the knee, and changing his feet like a flash, strikes the ball high from the back, with the opposite sole, for another player to vary the performance in as original a way as he can

Women, rather than men, are frequently the juggling experts described

Internationales Jongleur-Archiv Karl Heinz Ziethen

Prince Maximilian Wied-Neuwied, in his 1843 *Travels in the Interior of North America*, found that among the Mandan Indians "the women are expert at playing with a large leather ball, which they let fall alternately on their feet and knee, again throwing it up and catching it, and thus keeping it in motion for a length of time without letting it fall to the ground." From Isabel T. Kelly's 1934 *Ethnography of the Surprise Valley Paiute*, we learn that "three marblelike stones were juggled by women. One woman would bet another; she juggled until she missed, whereupon the other took her turn." And more recently, Charles Hillinger, a staff writer for the *Los Angeles Times*, reported in 1978 that Nuku'alofa on the South Sea island of Tonga may have more jugglers per square mile than any other place on earth. The women of Tonga have a centuries-old tradition of juggling, and all over the island—on streets and school grounds, at the seashore, and in tiny villages—young girls can be seen juggling at all times of day and night. Many of them are remarkably skilled, and Hillinger reports that some can juggle as many as seven limes or green *tui tui* nuts. At a contest held at the Queen Salote School, some of the girls, sitting on palm mats, were able to juggle for several hours without dropping a lime or *tui tui*.

The Tongan tradition of juggling appears to be indigenous, for it was first noted in 1774 by Georg Forster, a scientist on Captain Cook's second Pa-

Women often figure in accounts of juggling from around the world. Above: "Three ladies of Livuka," from the narrative Will Mariner, *published about 1937. One woman is shown "showering" eight balls, a record for this technique. Although posed, the photograph may depict an actual achievement. Facing page: Indian jugglers of the 1800s.*

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In 1932, Trixie, opposite page, was an outstanding girl juggler of rubber balls. She emigrated from Germany to the United States in the 1950s. Club swinging, which preceded the juggling of clubs as we know it today, was practiced by Georg Jagendorfer, right, in 1880. An eighteenth-century woodcut, below, depicts a French juggler.

The Bettmann Archive

cific voyage. Forster wrote of a young woman,

This girl, lively and easy in all her actions, played with five gourds, of the size of small apples, perfectly globular. She threw them up into the air one after another continually, and never failed to catch them all with great dexterity, at least for a quarter of an hour.

Similar accounts are available from others on Cook's voyages who saw children juggle as many as six balls. The report of William Mariner's adventures in Tonga is particularly important, for his description of the juggling reveals that it was accomplished by a method modern jugglers call showering, a relatively inefficient system in which all objects are thrown in a circular path from one hand while caught and passed back with the other hand. This makes remarkable the reports of native women juggling six objects; and a photograph in Adm. H.B.T. Somerville's narrative *Will Mariner* that shows a woman showering eight round objects, if authentic, documents a world record for the number of objects ever juggled by this method.

Evidence of the art of juggling can be found for the ancient civilizations of Egypt (especially in the paintings in the Beni-Hassan tombs), India, China, Japan, Iran, and even for the Aztecs and American Indians. Many of these dexterous practices were associated with religious rituals, and the presence of juggling skills among shamans in many of today's preliterate societies suggests a religious origin for them.

Among early Greeks and Romans, juggling was usually integrated with other skills such as acrobatics and sleight of hand. Despite the derivation of the term, juggling was not the central activity of the *joculatores*, the wandering entertainers of the Middle Ages, or the French *jongleurs*, who were primarily singers and minstrels. We know relatively little about the early British and European performers (and even less about the history of juggling in the rest of the world), but juggling apparently remained associated with legerdemain, or sleight of hand, for a long period. Thus, a classic work such as Reginald Scot's 1584 *The Discoverie of Witchcraft* fails to differentiate juggling from legerdemain. Both involve unusual manipulative dexterity, but in juggling the dexterity itself is publicly displayed (and applauded), whereas in legerdemain the performer's skill normally remains hidden from the audience and is the secret

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of the "miracle" seemingly effected.

By the early nineteenth century, juggling was becoming a specialized entertainment. An advertisement in the *Salem Gazette* of October 5, 1819, describes the "East Indian" Ramo Samee as having performed "for some time past in the metropolis of England, and before all the crowned heads of Europe, who have unanimously pronounced him to be the first master of the art in their dominions." Among his many feats, he included "a Series of Evolutions, with four hollow brass Balls, about the size of Oranges"; "Stringing Beads with his Mouth, and at the same time, as he balances, turning Rings with his Fingers and Toes"; and a "manly activity in throwing a ball, the size of an eighteen-pound shot, to different parts of his body with the greatest of ease."

Samee closed his act with a demonstration of sword swallowing so did not juggle exclusively, but he may be our earliest recorded "modern" juggler, antedating the Chinese juggler Lau Laura, who performed at London's Drury Lane in 1832 and who has usually been considered to be the first.

In the late nineteenth and early twentieth centuries, the art of juggling became conceptually separated from legerdemain and other types of entertainment (although many performers combined it with other displays). As sociologists have observed of many human practices, juggling eventually became a specialized activity of certain individuals. And as the role of juggler became institutionalized within the entertainment world, new subspecialty roles emerged. These included such diverse forms as the *Kraft-Jongleur*, or *jongleur de force*, who manipulated heavy objects such as cannon balls; the salon juggler, who juggled objects associated with the drawing room (top hats, canes, bouquets of flowers, billiard balls); the equestrian juggler, who performed while on horseback; the "antipodist," who juggled with his feet; and group jugglers, consisting of two or more persons tossing the same objects back and forth among them.

Many of the specialized jugglers were remarkable. The *Kraft-Jongleur* Paul Spadoni came into the circus ring dressed as a Roman and driving a chariot. After dismissing the horses, he proceeded to balance the heavy chariot on his head. The equestrian juggler Briatori juggled seven balls while standing on a moving horse. Many jugglers combined the new forms, and

A Roman terra-cotta figure of a male juggler.

Staatliche Museen zu Berlin

Enrico Rastelli, below and opposite page, considered by many to have been the world's greatest juggler, introduced the manipulation of large (six to twelve inches in diameter), air-filled rubber balls. It was not uncommon for him to practice ten hours a day, and his control was unparalleled. He died in 1931 at age thirty-five.

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The Japanese juggler Takashima, in about 1900. It was after seeing Takashima manipulate a cotton ball with a stick held in his mouth that Rastelli began working with large rubber balls.

Paul Cinquevalli, possibly the greatest of the late-nineteenth-century jugglers, combined acrobatic and balancing feats with his masterly manipulation of objects.

Non-Western jugglers who performed in Europe were very influential in the diffusion of juggling skills, and the English writer William Hazlitt discussed one such group in his well-known 1821 essay, "The Indian Juggler." Many European jugglers were impressed by Oriental performers who manipulated large balls of twine and yarn. After seeing the Japanese juggler Takashima, Enrico Rastelli began to manipulate soccer and other large rubber balls, a tradition still very much alive.

Rastelli (1896–1931), generally considered to have been the greatest juggler who ever lived, elevated juggling to a high art. Rastelli is to jugglers what Caruso is to tenors. His many feats included such incredible separate tricks as juggling ten balls, eight "sticks" (small clubs), or eight plates, and he was able to continuously bounce three medium-sized balls on his head. Many Americans saw Rastelli at the Hippodrome in New York in 1923. The world has since seen many great jugglers, some of whom have matched Rastelli's individual accomplishments. Massimiliano Truzzi and Francis Brunn duplicated many of Rastelli's tricks, and each set records of his own, but no one has yet matched the quality and breadth of Rastelli's achievements.

These truly great jugglers are known mainly only to professionals and to circus and juggling historians and fans, but many people are aware of the great comedian W.C. Fields's early career as a tramp clown and excellent salon juggler. Another outstanding comedian, Fred Allen, began his career similarly, but billed himself as "The World's Worst Juggler" after comparing himself with Cinquevalli and Rastelli.

Although juggling has its aficionados, most laymen do not appreciate the complexity of the art. There are several different systematic means by which objects can be rotated in the air. The most common approach is called showering and consists of throwing objects up with one hand while catching and rapidly passing them back with the other. This relatively inefficient system is used by most inexperienced persons who try to juggle and is probably the method used by most preliterate peo-

ples. Since one hand does all of the throwing, great speed is required to get the last ball into the air before the first one has come down to be caught.

The more professional way of juggling is called cascading, crisscrossing objects alternately by throwing them up and catching them using both hands in symmetrical fashion. While we have good records of people showering six balls, several people have now managed to cascade nine (Truzzi at one time did it regularly in his act).

Another form of juggling, for which there is no standard term, might be called pairing. Here half the objects are juggled separately by each hand, in an alternating rhythm that creates the illusion that the objects interweave. Because of the natural rhythms of the two patterns, pairing is normally used for juggling an even number of objects, while cascading is used for an odd number. Many jugglers use one system exclusively. Thus, a pairing juggler who can juggle six objects would increase the number by going directly to eight. Rastelli was such a "pair" juggler, and few people know that although he managed to juggle ten balls, he was, in fact, never able to cascade nine.

In addition to the various juggling systems, different types of objects require special efforts. Hoops are generally considered the easiest objects to juggle in large numbers because it is relatively easy to stop the action by thrusting one's hands and arms through the hoops, whereas ending by catching five balls in each hand is in itself difficult. Sticks and clubs need to be handled by the proper ends, thus requiring a set number of rotations in the air, and clubs are so wide that special care is necessary to avoid midair collisions. Plates generally are pair juggled because their rims make them easier to catch with the bowl side of the plate consistently toward the inside so the fingers can properly grasp the rims. These differences are important in limiting the maximum number of objects it is possible to juggle. Thus, the current world records are: eleven hoops, ten balls, eight sticks, or eight plates. Matters become even more complicated when a juggler mixes different objects (in both shape and weight) or does such things as use knives or flaming torches. Given the speed of objects falling through gravity and the height limits to which humans can throw objects into the air with adequate control, it may be impossible for anyone ever

Internationales Jongleur Archiv Karl-Heinz Ziethen

Famous contemporary jugglers include Francis Brunn, above, who developed a faster technique for juggling balls. His sister Lottie Brunn, left, also a juggler, emigrated from Germany to the United States.

Collection of Hovey Burgess and Judy Burgess

to juggle more than a dozen objects.

Despite the decline in circuses, vaudeville, variety shows, and other forms of entertainment with which juggling has been associated, the quantity and quality of juggling are today at a record level. Russia's extraordinary Sergei Ignatov, a star with the Moscow Circus, achieved the world record for hoop juggling—he cascaded an incredible eleven—and in the United States the remarkable eighteen-year-old Albert Lucas (Moreia) recently matched the earlier world record, set by the German Francis Brunn, by juggling ten hoops in a full rotation, as opposed to merely flashing (tossing and catching them only once).

The number of people interested in juggling in the United States has increased greatly over the last ten years, and we may be experiencing a veritable juggling renaissance. Juggling has become popular among students on many college campuses, and the publication and brisk sales of several new books on how to juggle suggest that tens of thousands of Americans now practice the art, at least minimally. The International Jugglers Association (mainly a U.S. organization, started in 1947) today has about 800 members, many of whom are highly skilled and most of whom are amateurs.

Why do people juggle? One important consideration is that the juggler, unlike the magician, can act as his own audience. The dexterity of the juggler is largely a self-testing behavior in which the achievement may be its own reward. And the criteria for excellence are largely objective: either one can or cannot juggle seven balls. Most other performers can manage to cover up an error, but dropped objects speak for themselves.

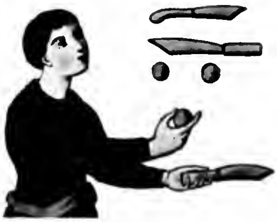
A juggler can practice a trick over and over without error only to fail when performing for an audience. Practice never really makes perfect, and a great deal of frustration invariably accompanies juggling. Some psychologists believe that perseveration, or persistence, can be a major organizing principle of personality. Whether this is true or not, the accomplished juggler must be persistent. Serious jugglers such as Rastelli have been known to practice up to ten hours a day for many years.

John M. Roberts, an anthropologist at the University of Pittsburgh, has developed a theory of "conflict enculturation" that may offer some insight into the motivation of amateur and pre-

Indian clubs have always been popular with jugglers and have been used by group juggling acts, as well as individuals. The Five Jewels, above, were a well-known group in the thirties, while Darmody, right, performed about the turn of the century.

Collection of Bobby May

Collection of Hovey Burgess and Judy Burgess



Specific skills are required for the juggling of each kind of object, and the juggling of different objects in combination presents further difficulties. Far left: contemporary artist Gipsy Buglione Gruss. Left: a medieval juggler. Below: a late nineteenth-century poster for "The Mighty Cradoc."

Circus World Museum, Baraboo, Wisconsin; collection of Hovey Burgess and Judy Burgess

Collection of Hovey Burgess and Judy Burgess

Rastelli was so versatile a performer that at one time his solo act lasted a full forty minutes. He manipulated a variety of objects, including sticks and torches. Facing page: Sergei Ignatov of the Moscow Circus set a world record by cascading eleven hoops. Although not comparable to Rastelli in breadth of performance, today's juggling stars are pushing at the limits of the medium.

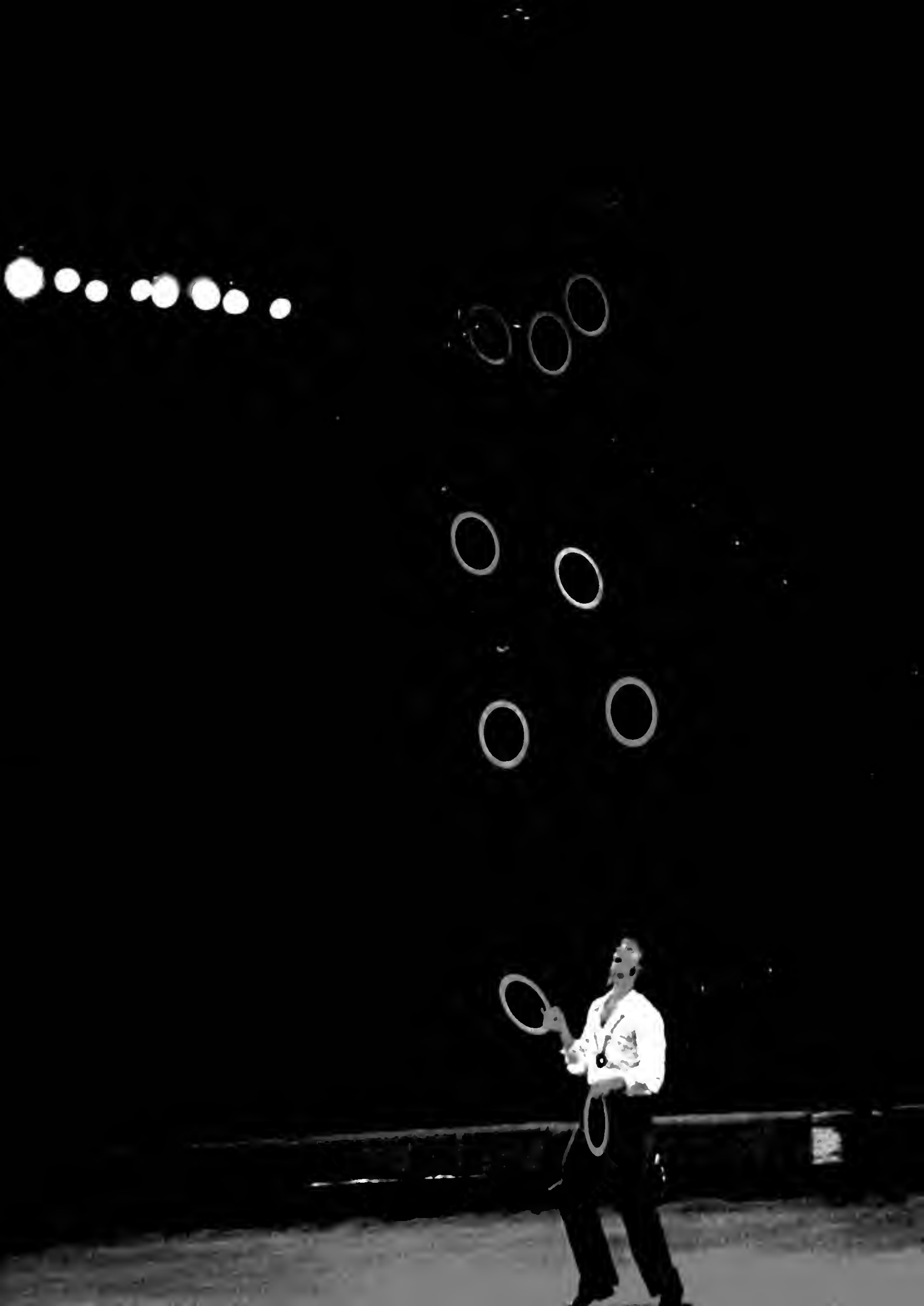
literate jugglers. He believes there are certain tensions induced by child training and subsequent learning that people deal with through involvement in games and other expressive models. In his extensive research on cross-cultural differences in games and play, he has been able to show that numerous expressive self-testing practices—ranging from games of physical skill to self-testing by automobile drivers on our highways—are associated with societies whose patterns of socialization tend to produce conflicts over achievement and self-reliance. Although the ethnographic data on juggling practices are too sparse to demonstrate the accuracy of Roberts's hypothesis in this area, the available evidence appears to fall in line with his other observations.

Juggling sometimes involves competition with others, both directly and indirectly, in games and sports (the presence of juggling skills in soccer and basketball are good examples of their indirect use). There was, for a time, an annual International Festival of Jugglers in which contestants vied for the Rastelli Trophy, but juggling as a competitive sport still has a long way to go before it reaches the Olympics. For most jugglers the competition is mainly with their own past performances. And one should also keep in mind that group juggling is an extremely cooperative activity.

Jugglers usually learn the details of their art from other jugglers. There are notable exceptions, but most great jugglers have modeled themselves after some other great juggler under whom they studied at least informally. Thus, advanced juggling techniques found in different societies are most likely the result of diffusion rather than independent invention. While association with other jugglers will not turn someone into a juggler, the teaching of the skills and the social support given a novice are probably important factors in accounting for both how and why many people learn to juggle.

The continuing juggling traditions around the world and the large number of people who practice juggling provide a wide base from which excellence can spring. In addition, modern technology now allows the production of highly uniform and carefully balanced juggling equipment, which most past great jugglers did not have. All of this strongly suggests that new juggling records will soon be set. Rastelli may yet be surpassed. □

Roger Dollarhide



La Gran Iguana de Mona

On a small island in the Caribbean lives a very large lizard

Text and photographs by Thomas A. Wiewandt

No lizard has made a more vivid first impression on my mind. The creature standing before me on the desolate plateau looked like some mythical beast of Egyptian design. Its head and body were enormous, its legs stocky, its tail uncommonly short. Two peculiar bulges crowning the head and the giant, sagging jowl muscles seemed improbable. Its intricately wrinkled skin and massive head ornamented with prominent ridges, enlarged spines, and horn on the snout gave the animal a ferocious, prehistoric appearance. When it tossed its head upward, it rolled in an uncoordinated fashion. I had maneuvered to within touching distance, but the iguana, tense and defiant, just remained poised at the edge of a crevice, holding its tail up off the ground, straight and stiff to the tip. Its forequarters swayed slowly back and forth, as though the animal was ambivalent about staying to observe me a bit longer or retreating to the security of its hole. Only the flash of an opaque white nictitating membrane, crossing the surface of its deeply set eyes, interrupted the creature's penetrating stare. Meeting this extraordinary iguana in its domain—a terrain marked by sharply weathered limestone, intense heat and glare, stark silence, and the delicately blended aromas of sea, frangipani blossoms, and pungent shrubbery—was a humbling, primordial experience.

This iguana dwells on an unusual island—a vast, bean-shaped slab of sedimentary rock situated midway between Puerto Rico and the Dominican Republic. Called "Amoná" by the small community of Taino Indians who were living there when Columbus arrived in 1494, it thereafter became known as Mona. Recorded history about the island spans nearly 480 years and has been meticulously traced by Frank H. Wadsworth, chief scientist at the Institute of Tropical Forestry in Puerto Rico. Continuous inhabitation of Mona by humans ended with the collapse of the Taino civilization some 400 years ago, and since that time human activity has been sporadic and generally confined to small areas. For nearly three centuries, the island was a hideaway for pirates. Between 1848 and 1927, bat guano was extracted from its caves. At the turn of the century, Mona was attached politically to the government of Puerto Rico, and aside from the guano mining episode, it has been used primarily for hunting and fishing.

In 1972, when I began fieldwork on the Mona iguana's life history, an average of six persons were stationed on the island—Coast Guard, police, and maintenance crews, all on rotating duty from the mainland. A single road crosses the island, connecting an old lighthouse on the East Cape with an assemblage of six government-owned cabanas near the West Cape. Introduced goats, pigs, cats, and rats populate the island, and as an employee of the Puerto Rican Department of Natural Resources, I was assigned to study their impact on native flora and fauna.

Three years later, I emerged from the adventure with an intimate view of the iguana's life style and a haunting concern for the future of Mona's wilderness, clearly one of the most precious remnants of West Indian natural heritage to be found anywhere in the Caribbean. As in other remote and relatively undisturbed small-island ecosystems, the unusual character of Mona's wildlife, rather than species diversity, makes it of special interest.

The island has a high proportion of endemic forms—more, in fact, than all of Puerto Rico's other offshore islands combined—and supports substantial populations of animals that have become rare and endangered on the Puerto Rican mainland. For example, 70 percent of Mona's terrestrial amphibian and reptilian fauna, including the iguana, is endemic, and it is one of the few places in the Caribbean where the endangered hawksbill sea turtle still nests in significant numbers. The island has recently been declared critical habitat for the Mona iguana, hawksbill turtle, Mona boa, and yellow-shouldered blackbird. All four appear on the list of threatened and endangered species issued by the U.S. Department of the Interior.

Together with its tiny sister island, Monito, Mona is also a haven for nesting frigatebirds, tropicbirds, boobies, terns, and laughing gulls, a sea bird colony rated by ornithologist Cam Kepler of the U.S. Fish and Wildlife Service as among the most outstanding in the West Indies. National Park Service cave specialist James F. Quinlan has described the caves penetrating the island's coast as the "most extensive and most unusual sea caves in the entire world." These are only a few of the island's distinctions.

Even the briefest conversations about Mona always come to the subject of iguanas, in fact or fancy. The Mona iguana belongs to a group of about eight species, commonly known as ground iguanas (genus *Cyclura*), that frequent rocky habitats of eroded limestone in the subtropical-dry climate of the Greater Antilles and the Bahamas. The largest native land vertebrates to have survived in the Greater Antillean faunal region, they are also among the largest lizards in the Western Hemisphere. While males of one or two species may rarely attain lengths of five feet, the Mona iguana (*C. stejnegeri*)

Chomping on a manchineel fruit, a Mona iguana consumes one of its favored food items. The fruit can cause stomach ulcerations, and even death, in humans, but it is not toxic to the iguanas.

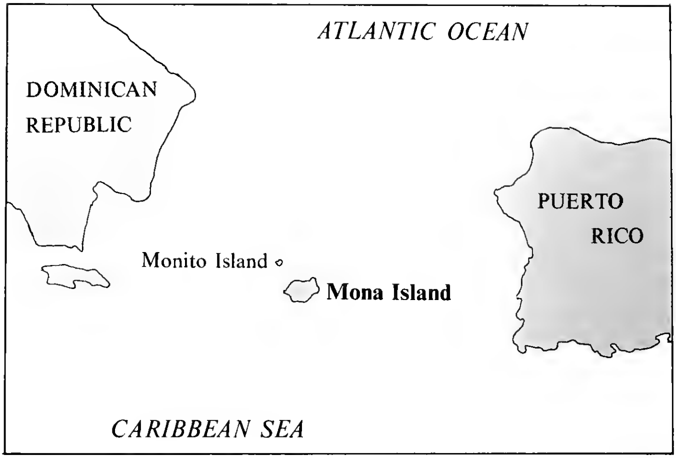
reaches a maximum overall length of about four feet and weighs fifteen to twenty pounds.

Long before adventuresome humans found themselves on Mona, tough-bodied iguanas were there, reshaping their ancestral ways through millenniums of natural selection and adaptation. This slow process of ecological perfection is reflected in the animal's outward appearance, social behavior, and other life history attributes. The process, of course, must have been well under way in Hispaniola before iguanas first reached Mona—presumably transported there by waif dispersal at sea.

Almost 95 percent of Mona's 13,600-acre area is a relatively homogeneous, slightly domed, and undulating tableland, limited around the windward, northern perimeter by sheer cliffs that drop some 150 to 280 feet to the sea. The cliffs of the south side are steep, but break away in many places as talus slopes that descend to a narrow coastal terrace 10 to 12 feet in elevation. Rainfall averages 32 inches annually, but because of its highly permeable limestone substrate and general lack of soil, Mona has no watershed and only supports a slow-growing forest of xerophytic shrubs and trees. Surface depressions in the rock, a few of which exceed three feet in diameter, catch and hold rainwater for periods ranging from hours to, occasionally, months. Water also collects seasonally behind rimstone dams in some of the caves. The scarce accumulations of soil on the plateau are confined to small, shallow potholes and sparse sinkhole depressions. The coastal terrace is mantled with a thin, spotty layer of sandy soil.

Mona's rocky terrain is honeycombed with crevices and water-worn passages that house iguanas. At times such hideaways are shared communally by the lizards, but by and large, they are solitary in habit and are seldom seen together outside the breeding and nesting seasons. When crossing Mona on foot, one can expect to encounter approximately one animal every three-quarters of a mile. The island's subtropical maritime climate permits iguana activity year-round. Yet curiously, a segment of the population normally remains underground and inactive, even during clear, sunny weather when other iguanas are moving about.

This behavior becomes less puzzling in the context of how these animals



spend their waking hours. About 95 percent of a Mona iguana's normal daily activity is devoted to rest, with or without basking, and feeding is not a daily requirement. Furthermore, the best way for an iguana to avoid or terminate a social confrontation is to go underground, a tactic of special value to subordinates. Only dominant territorial adults, those that would benefit most by being ever present and conspicuous, spend most days and nights at the surface. Mona iguanas do not need to make daily appearances to remain healthy and can sometimes benefit from a low activity profile.

Retreats offer these ectothermic vertebrates a stable microclimate permitting conservation of precious body water and energy. Within these niches, the air remains humid and the temperature nearly constant throughout the day. The temperature, year-round, ranges from 73° to 86°F, approximately half the annual variation that occurs aboveground.

Mona iguanas are chiefly herbivorous, with some animal foods taken opportunistically. Strongly favored plant species and plant parts are those low in cellulose, low in aromatic compounds, and easy to obtain. Theoretically, these are food types that would be predicted if the lizards were to harvest what is available for maximum net energy gain. The diet of juveniles is similar to that of adults, except for differences in the size of food items eaten. A large proportion of Mona's native trees and shrubs bear fruit under ⅗ inch in diameter, which the iguanas prefer over leaves. In fact, when readily available, fruits are invariably taken to the near exclusion of leaves. In spite of their seasonal occurrence, fruits are the principal plant foods contributing toward growth, reproduction, and fat reserves.

One popular item in the diet of adult iguanas is the fruit of the manchineel tree. When consumed by humans and other mammals, the ripe green fruit of the manchineel can cause stomach ulcerations, sloughing of the gut lining, and even death. Their aroma is sweet and intense, a temptation to people and iguanas alike.

The Mona iguana only eats animal foods that are nearly as easy to catch as a fallen leaf. Items of greatest significance are large, slow-moving insects that can be found on the ground and in periodic abundance. By far the most marked cycles observed were those of the large sphingid moth *Pseudosphinx tetrio*. Its larvae are host-specific on Mona to the abundant arborescent shrub *Plumeria obtusa*. Plants of the genus *Plumeria*, also commonly known as frangipani, or *alelí*, are widespread in the neotropics, where they are often accompanied by *Pseudosphinx*. These caterpillars have brilliant aposematic coloration—red, orange, and yellow in contrast to black—and typically reach about five to six inches in length before pupation. The milky sap of the host is reputed to be mildly poisonous, and caterpillars feeding on the plant presumably carry the toxins in their tissues, which gives them protection from predatory birds and mammals and explains the origin of their warning coloration.

But once again, the iguanas' gustatory preferences are not in step with

those of higher vertebrate groups. After first observing one of these caterpillars in June 1973, I found that within thirteen weeks, a population had developed that spread like a wave of disaster across Mona's landscape, stripping nearly every leaf, fruit, and flower from the *alelí*. Everywhere caterpillars were dispersing and dying on the ground in their search for more food, and the iguanas were gorging themselves. Scats turned into puddles of gray-green ooze containing empty caterpillar skins and little else. Every iguana seen, large and small, had a face blackened from dried caterpillar juice. *Pseudosphinx* pupate in leaf litter, and the iguanas were also feasting upon these giant pupae. The inevitable population crash followed in late September and early October. Caterpillars were rare during the winter months, ebbing in January 1974 as the *alelí* sprouted new leaves. A minor resurgence occurred in mid-February, and a second major population peak developed in early July. This phenomenon has since passed; although the moth is still present on Mona today, its density has remained low, with breeding being relatively asynchronous.

Among the most widespread behavioral attributes in wild populations of vertebrate animals is territoriality. The term, used here in the traditional sense, denotes an animal's defense of a fixed area from conspecifics by means of advertisement, threat, or attack. Functionally, territories are structured around any one or a combination of requirements critical to the animal's survival and reproductive success, for example, shelter, food, mates, and nest sites. Viewed as a product of natural selection, territoriality is likely to evolve and be maintained only under circumstances where the risk or energy costs associated with the defense of a particular resource are low relative to the benefits derived. One could predict, for example, that Mona iguanas should not maintain feeding territories since foods of greatest significance in the animal's diet tend to be patchy in time and space and locally abundant when available. Such food would be impractical to defend. These lizards, in fact, usually forage in areas that remain undefended.

Possessing a piece of real estate containing retreats attractive to females is the usual prerequisite to breeding in male Mona iguanas. Females seem to select retreats according to location and structure. Proximity to choice food resources is important, and preferred retreats appear to provide good drainage, ventilation, and a nearly horizontal resting place under a low ceiling and within five feet of the surface. Remaining fairly close to the surface helps the animal monitor conditions aboveground. Individuals inhabiting caves roam the twilight zone but do not venture into total darkness.

Serious challenges over mating territories are resolved through fighting. Fights among adult males are highly formalized tests of strength—face-to-face pushing matches, with mouths stretched wide open. Most clashes last less than fifteen minutes and end without violence when one or both iguanas back slowly away in retreat. Disputes taking longer to settle, some continuing for nearly an hour, involve biting and tail-lashing attacks. Confrontations seen with one male clamped onto another's snout suggest to me that the distinctive horns may function as defensive weapons that help disengage an opponent's hold. With jaws interlocked, contesting heavy-bodied lizards risk serious injury, a risk that might favor this ornamentation. The lizard's lateral spines and the cushion-like parietal bulges crowning the head afford added protection during combat and, like the nasal horns, could also act as protective armor against the sharp limestone rock. The sagging jowls are solid muscle masses used for biting, and their hypertrophied appearance may be display related, an advertisement of fighting ability.

Mating takes place annually during a two-week period. At this time females seldom venture more than several feet from the safety of a retreat. Although sometimes accepting a male's advances without hesitation, females must often be patiently, yet forcefully, coerced. A male that has located a female within his territory sits or lies in waiting six to ten feet from her retreat, his eyes fixed on the hole. When she appears, he displays to her with a series of toss-roll head movements, dashes to her with his head lowered, and pauses briefly by her side for another round of head displays. At this point, he grabs what he can, often biting her tail or loose skin on her flank, to restrain her while he maneuvers to a better position, a neck-hold and straddle over her. An unwilling female may turn to bite or, more commonly, struggle into a crevice, dislodging the male in the process. The male may follow her into the hole, but typically he backs off to await her reemergence.

This sequence of displaying, pursuing, pinning, and losing a female may continue for hours or days. The female's stay in hiding grows progressively shorter with each assault, and the fleshy flap of skin on her neck may become raw and bloody before she submits. Even after successfully pinning his mate, a male often lets go, bites, and pulls repeatedly at the crest on her neck, as though providing added stimulation to the area. The effect appears to be pacifying, and the female usually goes limp before copulation is attempted. Sometimes the female is also dragged about a bit, and her forequarters tossed to and fro during the preliminaries.

Numerous variations were observed in the individual style of courting males. Some males handle the task with great finesse, while others appear overanxious and clumsy. It was, for example, amusing to see one male rush up to a female and nab her gently by the skin of her cheek, while another male (Four-toed Freddie), never pausing to display, charged at his prospective mate (Lora) and grabbed her by the head, as though to engulf her. Intimidated by Freddie's tactics, Lora fled for cover. Freddie had several similar opportunities to court Lora that same afternoon and the following morning in the same place; on these occasions, however, he approached her so meekly that he was totally ineffective. He sat watching her and displaying to her repeatedly and even walked around and over her, but he never again attempted to seize her. Later that second day, three males mated with Lora in succession, and Freddie lost out altogether. It thus appears that individual experience may play an important role in the development of behavior patterns in these lizards, a quality that would be of particularly great value to a long-lived species.

Copulation lasts a brief one to two minutes. After uncoupling, if the female attempts to leave the male's territory, he invariably pursues her and tries to circle around in front to intercept her. Because females often mate with more than one male during their brief period of receptivity, this postcoital guarding behavior is presumably one way a male can help to protect his reproductive investment. A female's ability to store sperm, a trait characteristic of many reptiles, makes it highly probable that insemination by

more than one male will produce a clutch of eggs fathered by more than one male.

Altogether, we can say that a male's breeding success depends chiefly upon the frequency with which he encounters females, his ability to catch a receptive female quickly, mate with her without interference from competing males, and keep her from contacting other males between insemination and fertilization. The males' breeding territories, where these objectives are accomplished, differ appreciably in physical structure and attractiveness to females. These differences also determine how easily a male can defend his claim. A physically simple site that contains only one or two retreats used by females can be readily guarded by a resident male. In contrast, a structurally complex site, for example, a pile of boulders with a network of passages leading to interconnecting underground chambers that provides shelter for numerous females, is particularly difficult to monopolize. Intruding mature males, attracted to the localized concentrations of females, need only dive into the nearest hole to escape a challenge.

Two remarkably different reproductive strategies employed by adult males, both based on territorial behavior, were discovered and compared side by side through studies of iguanas resident at a sinkhole depression on Mona's plateau. Iguana habitat in the study area was structurally variable, and the social environment was highly competitive. One slope of the depression contained a complex network of retreats that housed 77 percent of the resident females and 58 percent of the males. Here, the only effective male reproductive strategy was to defend a miniterritory (roughly twenty feet in diameter) only during the breeding season. At this site, males that attempted to monopolize larger territories or to preempt other males by staking out a claim well ahead of the season were readily defeated through repeated challenges from rivals once mating activity began.

On the other hand, in areas that were frequently traversed by females but offered relatively few retreats, competition between males was less intense and territorial behavior became more feasible and less costly. Under these circumstances, a male could improve his chances for successful mating by maintaining a relatively large territory year-round and extending the courtship period. The longer such a territory is defended, the less likely that trespassing will occur during the breeding season. Furthermore, a male that continues throughout the year to court potential mates walking through or residing within his territory is in a better position to monopolize them when the critical time arrives. The greater her familiarity with a resident male, the more likely a female will be to seek out or stay within his domain and accept his advances when she becomes receptive.

During the breeding season, males making the long-term investment engaged in roughly half as many chases and one-fourth as many fights, and their average mating success was four times greater. Territories held by the long-term males were at least twice the size of those defended by short-term strategists. Mating success proved to be low among the short-term strategists for two apparent reasons: their territories being small, and in proximity to neighbors, interference from competing males was correspondingly great, and the resident females avoided competitive strife between males and generally attempted to move into other areas for mating. Thus, even though the probability of encountering females in these small territories remained high, a male's chances for completing copulation there were relatively low.

Long- and short-term male reproductive investments do not appear to be mutually exclusive behavior patterns. Young males most likely begin as "floaters" until they acquire the strength and experience to hold a breeding territory. Thereafter, the strategy employed probably hinges primarily on the defensibility of available territories, with the older and more dominant males securing those territories permitting both access to females and year-round defense. As social conditions change over the years and vacancies appear, individuals may shift from one system of territorial behavior to the other. Because one would expect males to advance from a less efficient to a more efficient system with respect to mating success, the usual direction of change is probably from a short- toward a long-term strategy.

Approximately one month after mating, the most demanding annual event in the female's life begins: nesting. Eggs are buried where they can be warmed by direct sunlight throughout much of the day and where the soil is sufficiently deep and stable to support a blind tunnel approximately three feet long. This excavation terminates in an egg chamber just wide enough to allow the female to turn around. After laying a single clutch of five to nineteen soft-shelled eggs, the iguana refills the passage by kicking soil into the hole entrance and working it down into the tunnel by pushing it ahead with alternate use of her forefeet. Then, by repeatedly ramming her head into the loose fill, she tamps the earth in place. This process continues until all signs of the entrance have been obliterated. The egg chamber, however, is never filled with sand, leaving a pocket of air over the eggs that is apparently essential for proper embryogenesis and hatchling emergence. Under the best circumstances, hole preparation, egg laying, and covering operations require one full day.

Less than one percent of Mona's surface area offers conditions suitable for nesting. Most attempts to dig in potholes on the plateau are abandoned because of insufficient soil. Consequently, gravid females generally migrate to the few inland sinkhole depressions and to sections of the coastal terrace where soil reaches its greatest depth. Those first to arrive begin by examining holes left in the ground from the previous summer's activity, for only about half the excavations started are used for egg-laying. A little trial digging usually accompanies the inspection of each and if none proves acceptable, a fresh hole is started. This pattern goes on throughout the nesting season, with newcomers attracted by both unoccupied and occupied holes. Deeper holes receive the most attention. Should a burrow collapse or the digging become too difficult, the spot is deserted. As the number of iguanas searching for nest sites grows, competition among females intensifies.

Difficult digging has encouraged females to exploit the efforts of their neighbors. It is not uncommon for one female to take over a hole that another has started. Eviction may be forceful,

Fighting over breeding territory, two males engage in a pushing match. This test of strength usually lasts less than fifteen minutes, and little physical harm is done in these formalized battles.

through repeated antagonism, or the takeover may occur passively should the occupant vacate the hole at nightfall or because of intolerably hot conditions. The soil temperature in nesting areas often exceeds 122°F at the surface, and to avoid overheating, the iguanas must sometimes retreat to shade. Furthermore, because gravid females find easy digging in the loosened soil over closed nests, they are a threat to the eggs within. Iguanas digging into unattended nests kick out any eggs encountered, as if they were stones. This pressure has been countered by extended maternal care in the form of nest guarding. Instead of simply abandoning the site after nest covering, the pattern typical of most lizards, female Mona iguanas generally return for one to ten days to inspect the area for disturbance and stand guard against intruders. Any new holes within six feet of the original nest entrance are filled, and females crossing the site are chased when possible.

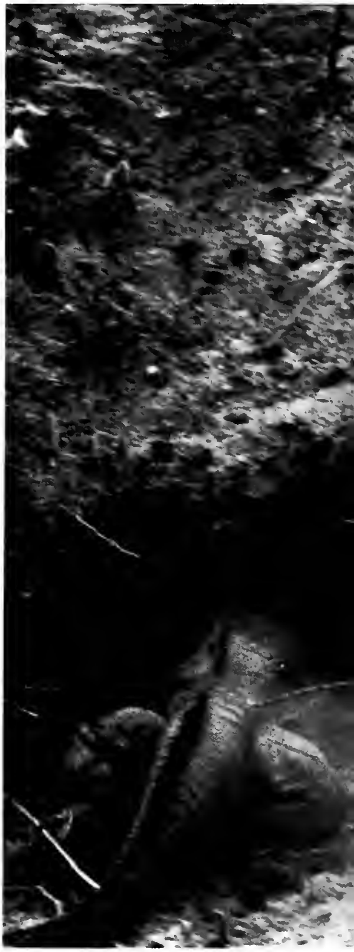
Defense tactics used against persistent intruders that begin digging include head-rolling displays, a broadside challenge display, huffing, biting, tail lashing, and delivering sand back into the hole and on the rival. Even though a relatively small resident may be chased from her nest and unable to hold her own against larger challengers, she will always return promptly to resume the harassment.

I have the impression that temporary dominance relationships are occasionally established between females nesting concurrently in the same area, and have found evidence—the first of its kind for reptiles—that these iguanas

A spent female crouches over the entrance to her nest in defense against a larger, intruding, gravid female. A fight erupts, after which the intruder digs toward the egg chamber while the defender kicks soil into the burrow. The intruding female will destroy any eggs in the chamber and lay her own.

have the discriminatory ability to recognize each other as individuals. Two nest owners permitted their nearest neighbors, who were also defending completed nests, to sit and lie directly upon their nest sites, whereas all other iguanas, gravid or spent, large or small, were chased from the vicinity. In both cases the behavior appeared on the second day after the neighbor had completed her nest. Before that, neither had tolerated the presence of the other within a radius of about three feet around the original nest entrance.

Female Mona iguanas are strikingly similar to males in outward appearance. They have equivalently well-developed cephalic horns, a middorsal crest, and a dewlap (throat fan). Older females also have large bodies and enlarged, sagging jowl musculature. It is thought—an old thought developed in a book about sexual selection by Charles Darwin—that in the many species where males are the showier sex, the larger, more ornamented individuals are those best able to attract or compete for mates. But why should female Mona iguanas be endowed with



malelike attributes? I suspect that female–female competition for nest sites has had the same evolutionary consequence as male–male competition for breeding territories. Such physical characters, together with display repertoires used during agonistic encounters, exaggerate the animals' apparent size and ferocity. In both sexes, fighting preliminaries typically include broadside challenge displays, which feature circling and prancing with spinal crests elevated, sides flattened, and heads held high. In Mona's ecological setting, large females best built for fighting and putting on an impressive challenge display at nesting grounds should experience the greatest reproductive success.

The length of the iguana nesting season on Mona is short; nearly all digging and laying activity is concentrated within an eleven-day period. The season begins at the same time every year and is apparently cued by photoperiod. I believe that the interplay of climate and behavior best explains the duration and timing of the nesting cycle. The island's climatic regime appears to determine how late in the year an iguana can nest successfully. Hatching normally occurs about three months after laying, in October and early November; these are the two wettest months of the year, providing optimal conditions for juvenile emergence, feeding, and dispersal before the characteristically abrupt onset of the annual dry season in January. Late nesters would probably suffer a heavy loss of hatchlings during their first six months of life.

How early the nesting begins appears much more closely tied to competition for nest sites than to climatic factors. Early-arriving females run a high risk of losing their eggs to disturbance by the latecomers. Although the likelihood of this is lessened by nest defense, there is a limit to how long a female can profitably stay to fight off intruders. Under conditions of intense competition, nest defense is energetically taxing and the risk of physical injury is considerable.

As with sea turtles, the emergence of young iguanas from the nest is a team effort. In general, all eggs in a given clutch begin hatching within a 24-hour period, and the young spend one to two days freeing themselves from the eggshell. They must then free themselves from their underground prison by digging through the packed soil. Their escape holes rarely correspond with the original tunnel dug and refilled by the female. The young dig as a group, and those last to hatch are sometimes buried alive by their siblings, accounting for about one percent of the in-nest mortality. Infertility and improper development claim about 14 percent of the eggs in undisturbed clutches. The effort to escape from the nest chamber may typically require from a couple of days to a week or more. Without cooperative digging and periodic rain to soften the ground, many hatchlings would most certainly die underground. The generous endowment of yolk carried by each hatchling presumably insures its survival during this critical stage.

Eggs and hatchlings of the Mona iguana are huge. Typical straight-line dimensions of the eggs are 2 by 3¼ inches, roughly the size of goose eggs. Hatchlings average 12.6 inches in overall length and 2.6 ounces in weight. While eggs of the Galápagos marine iguana are the largest known for any lizard in the family, those of the Mona iguana run a close second, and hatchling length is essentially identical in the two species. Iguana populations on oceanic islands, where natural enemies are few, can afford to produce smaller clutches, with eggs and hatchlings of larger size, than would be possible in most mainland ecosystems. Ecological factors that encourage a stepped-up investment in individual progeny are undoubtedly diverse, varying with respect to both local conditions and the lizard's habits. Increased size reduces susceptibility to desiccation and lowers energy requirements per unit of body weight. In Mona's environment, large hatchlings would also have a greater variety of important foods at their disposal, especially fruits, and would be exposed to predation for less time. This could be of great consequence since hatchlings are near the upper prey size limit for two species of snakes and the sparrow hawk, a locally abundant resident.

Once out of the nest, each hatchling must fend for itself. The young quickly disperse to areas that provide adequate food and cover. Unlike adults, small juveniles have pronounced disruptive patterning, which presumably reduces their vulnerability to predatory birds. This banded pattern fades when the lizards are about three years old and have reached the size at which they are no longer suitable prey for raptors.

Although at present we have no meaningful longevity records or reliable techniques for determining their age, Mona iguanas and perhaps all of the larger species of *Cyclura* are probably among the longest-lived lizards in the world. They have no native predators to fear as adults, thus optimizing life expectancy. In addition, their slow life style and relatively slow growth—females require six to seven years to reach maturity—are features strongly correlated with increased longevity in animals. I would guess that these reptiles commonly reach thirty to fifty years in age and that some may live twice this long.

More than 90 percent of the world's species and subspecies known to have gone extinct during the past three centuries were island forms. Among those diminishing at an alarming rate are West Indian ground iguanas. Of the nineteen named, morphologically distinct forms currently recognized, three—and possibly a fourth—have become extinct in recent times, five (including the Mona iguana) are seriously threatened, and eight are fragmented into tiny populations of variable status. Humans have clearly been the prime cause of the group's demise, either directly through hunting or indirectly by giving livestock and household pets free range, importing exotic predators (such as mongooses), or otherwise modifying critical aspects of the lizards' natural habitat.

Problems now confronting the Mona iguana are illustrative of the predicament facing the group as a whole. Introduced cats and pigs, plus normal human activity, are a serious drain on recruitment into the iguana population, while goats are busy devouring the island's prime wildlife habitat. With few exceptions, trees that bear fruit known to be important in the iguana diet are now unable to propagate successfully because of goat browsing. The Mona iguana is by nature docile and adaptively naïve to the devices of all mammalian predators. Juveniles are no match for the patience and speed of a cat. And adult females are oblivious to raids on their nests by hungry pigs. Even more important, the iguana's demographic traits provide no compensation against heavy losses of progeny: at best, females nest only once each year, they are late maturing, and clutch size is small. Juveniles are extremely scarce, suggesting senescence and declining population density.

Mona Island must be recognized and protected for what it is: a Galápagos-like West Indian wilderness. This means that features of the environment that make it special—its native biota, its scenic magnificence, and its wildness—most always assume priority in every planning effort.

Most people visiting Mona have a desire to learn something. If they are denied this opportunity—as they are now—one cannot expect them to have respect for the island's harsh, but fragile, character or regulations designed to protect it. An active research program has not continued on Mona, thus eliminating another vehicle for education and the foundation for sound management policy. Unfortunately, while the inventory of organisms inhabiting Mona has grown, the conservation needs of most remain unknown. Wise policy decisions must originate from a thorough acquaintance with the requirements of each resource. The extent to which Secretary Fred Soltero-Harrington of Puerto Rico's Department of Natural Resources, the present custodian of the island, and his successors develop a comprehensive program of conservation for Mona Island will largely determine whether this natural treasure will survive into the twenty-first century. □

Introduced goats (and pigs) have had a devastating effect on the vegetation of Mona Island. Plant successional patterns have changed, and many species that are useless to iguanas have become dominant.

Ephemeral Frontiers

In Venezuela, the last of the independent diamond miners lead a rugged existence

by David John Thomas

photographs by Sandy Hochhausen

The diamond mines of Venezuela have attracted men from all over the world. Found among the scattered diggings and cut-up stream beds, the palm or canvas shacks, are Italians, Czechs, Hungarians, Syrians, Lebanese, and most of all, Brazilians. There are also a few Pemon Indians, whose ancestral lands form the southeast corner of Venezuela. In Brazil these men are called *garimpeiros*, or "prospectors," while in Guyana they are known as "pork-knockers," presumably because of the salt pork they carry; in Venezuela they are simply *mineros*.

Pick-and-shovel diamond mining has been around in South America for more than two hundred years, but it became particularly important in the twentieth century as Europeans and South American nationals penetrated and expanded into various parts of the Amazon and Orinoco drainages. In the 1930s, the *garimpeiros* in the Brazilian state of Mato Grosso worked at the fringes of the cattle economy. After World War II, mining surged in Venezuela and in the Brazilian territories of Acre, Rondônia, and Roraima. But in 1970 the Brazilian government shut down the independent miners of Acre and Rondônia in favor of international consortiums and transferred the *garimpeiros* by air to Roraima. In a few years' time, when the consortiums have also taken over the diggings in Venezuela, the last of the independent miners will be gone and with them will go a frontier phenomenon that evokes the famous gold rushes of California and the Klondike in the last century.

Antonio examines his largest mesh suruca *sieve for diamonds, which may weigh a carat or more. His partner has emptied his first two screens and is double-checking the mounds for the glitter of diamonds.*

Like Dawson and Whitehorse, which were centers for the Yukon miners, Uriman, Icabaru, and other locations in southeast Venezuela are stepping-off points for independent miners. Uriman, on the middle reaches of the Caroni River, consists of a small airstrip and a bunch of mud- or concrete-walled buildings that have fallen into varying degrees of disrepair. It is quiet now, but in 1950 Uriman knew the first of a series of booms that brought miners into the area in droves. Ramon Peña, the local *patron*, or "boss," is known to the inhabitants of Uriman as either *comerciante* ("merchant") or *comprador* ("buyer"), as the occasion warrants. He recounts his story this way:

> Icabaru [a mining site on the river of the same name] was discovered in 1947. I spent four months at the mines then. Here, nearby, in 1950, some Italians found the mine called Abeki. They were hidden, working secretly. When the boom hit, there were six hundred miners overnight. But the governor closed the mines five days after I got there, and they flew the miners out by military plane. In '52, after the elections, they freed up the mines, and I came here as a *comerciante*.

Los Frijoles ("the beans") is almost a day's hard walk from Uriman, across the river and beyond a humpbacked mountain known as Morrocoy ("turtle"). The settlement comprises just a few palm-roofed lean-tos—with hammocks strung under them—and a kitchen shack. Various contingents of miners, numbering from two to five or so, have come and gone, leaving their marks in the open pits along the nearby stream bed.

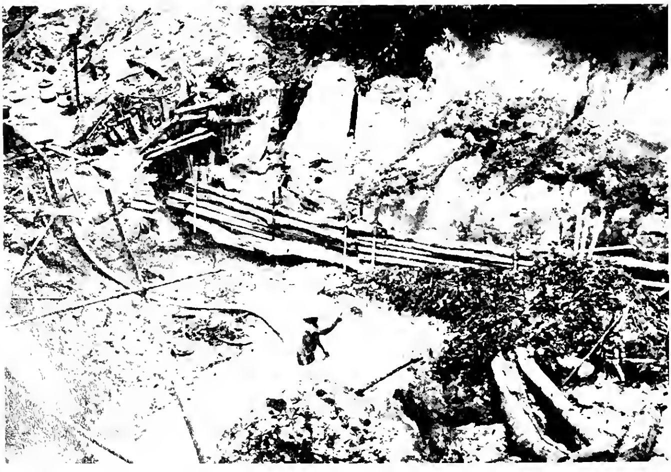
The miners work under a section of the Venezuelan mining law of 1945 known as *libre aprovechamiento*. According to this provision, anyone can explore and excavate empty lands, with certain restrictions. (Many of these so-called empty lands in southern Venezuela are actually occupied by Indian tribes, who have suffered the disruptive effects of mining while deriving little or no benefit.) The miners' deep excavations cannot exceed four square meters (4.8 square yards) in cross-sectional area, and each trench or other surface excavation cannot exceed one hundred square meters (120 square yards). Of course, if someone has filed a concession claim with the government, then only the concessionnaire and his employees are permitted to work the land for mineral deposits.

When they think they have found a likely spot, the miners often must dig down twenty or thirty feet to get to the diamond-bearing layer, or formation. The diamonds in this part of Venezuela have been deposited in scattered clumps, usually along or actually in the stream beds and riverbeds; there are few if any diamond pipes, as are found in South Africa. The miners work with a shovel, a bucket, and a set of sieves known by the Brazilian term *suruca*. The *suruca* is a stack of three circular sieves with progressively finer meshes. Standing in the pit, knee-deep in water, the miner shakes the top sieve, swirling the earth half in, half out of the water to allow the heavier stones to come toward the center. After handpicking through the sieve for the small gray white stones he is seeking, the miner proceeds to the next, finer sieve. When all three meshes have been used in succession, the leftover gravel and sand is dumped in a pile beside the pit.

The miners spend long, silent hours at the grueling work of *o surucazo* ("swishing gravel"). Clothing is minimal in the water-filled pits—swimming trunks, shirt, broad-brimmed straw hat. Shoes are useless and are saved mainly for trips away from the mines. A small, gasoline-powered pump is often needed to reduce the water level in the pit enough to permit work. During the rainy season, mining is often suspended because there is too much water in the pits.

The miner is up before dawn and,

His shop in Ciudad Bolívar helps support Zurita's diamond-mining ventures in the wilderness. Here, he arranges the supplies, while his experienced Pemon Indian helpers rest up for the river journey.



Logs shore up the sides of this nearly forty-foot-deep cut. A miner removes large stones and lumps of clay that are clogging the pump used to reduce the water level.

Agustín and León walk a canoe against the strong current of the Caroni River at a point where the shallow, swift water is dangerous. They must make this arduous trip to get supplies for the camp.

unless he takes time out for hunting or fishing, may work until dusk. A cup of coffee and a lump of bread usually do for breakfast, while most afternoon or evening meals include pasta, the ubiquitous staple. Some miners operating at sites such as Los Frijoles often clear plots by the slash-and-burn method so that they can grow manioc, corn, and sugar cane. Evenings are sometimes spent exchanging stories. Miners with transistor radios usually tune in to "Correo de Guayana," an informational program broadcast daily from Ciudad Bolivar at 6:00 A.M. and 7:00 P.M. The broadcast transmits messages from miners to their partners, friends, and relatives, for example, "Meet me in two weeks in Uriman with your partner so-and-so."

Miners work as partners, or *socios*, and share the proceeds equally, unless one is the owner of the pump, in which case he takes a bigger cut. The *socio* relationship lasts only until the diamonds have been sold; the miners are then free to go their separate ways or to join together in a new round of work. The miner continues his backbreaking labor until the site is played out or he cannot get any more credit for supplies. In one type of arrangement, known as *medio plazo*, an entrepreneur will stake miners to provisions and equipment in exchange for half the income from their sales. Such an entrepreneur usually owns equipment, has had experience in the mines, and is sharp enough to prevent individual miners from dumping diamonds on the refuse pile in order to return for them after dark.

The swift-flowing rivers and up-and-down trails of the upper Caroni region are long and arduous. Getting provisions into these areas is difficult, and the markup on goods of all types is enormous. Various small businessmen, transporting their wares by canoe from the nearest airstrip, sell everything from rice, salt, pasta, sardines, and other staples to transistor radios and sports clothes at prices three to four times those of Ciudad Bolivar, about two hundred air miles away.

The lines of supply to the miners are ultimately by air—either the workhorse DC-3s of World War II vintage ("U.S. Army Air Corps, 1943," says the plaque just inside one cabin), smaller one- or two-engine planes, or if the find is rich enough, costly helicopters that can land in a small patch of cleared forest. Private concerns operate cargo planes out of the airport in Ciudad Bolivar, and the government airline, Linea Aeropostal Venezolana (affectionately called *la ataúd volante*, "the flying coffin"), runs flights to the upper Caroni region on an average of three times a week. During a boom time, they may land four flights a day at the Uriman airstrip. If the boom is big enough, private messenger services, known as *representaciones*, transmit cash and messages by air from the miners to their relatives or friends in Ciudad Bolivar and elsewhere in Venezuela. Some equipment makers, including one American engineer from Texas, have set up shop in Ciudad Bolivar to supply mechanical rigs and pumping platforms for deep water and river work in some of the more intensely mined areas, they fly these rigs in by air.

A miner's life is a long series of wanderings, searchings, booms, and blow-outs. One miner I knew was a man in his forties from Sicily, who prided himself on his home baked bread. When I first encountered him on a mountaintop many hours upstream by canoe from Uriman, he was on the last six months of a four year stretch spent there with his Pemon Indian

In the village of San Salvador de Paul, a miner from the island of Barbados and a shopkeeper relax in the latter's grocery store. The village has grown with the discovery of fresh diamond deposits.

helper. Every six months, having mined just enough to pay off his debt to Ramon Peña, he had come downriver to Uriman to sell what diamonds he had, get new provisions (on credit), and throw a good drunk. He spoke of the work in the mines as difficult, but said proudly, "No one tells me when to get up in the morning." Whenever he could manage it, he would fly out of the airstrip at Uriman to Ciudad Bolívar, there to spend his gains on liquor and women until the money ran out. Miners, like horseplayers, most often die broke. There are fabulous tales told on the riverfront in Ciudad Bolívar of miners who blew $10,000 in two weeks and had nothing to show for it at the end.

As a seller, the miner is at the bottom of a long marketing chain, which stretches from the remotest parts of Venezuela, Brazil, and other parts of the Amazon area to local centers, such as Ciudad Bolívar, to national metropolises, such as Caracas and São Paulo, and on to the world market centers of New York, London, and Amsterdam. The miner sells his diamonds to the *comerciantes* or to local diamond buyers, many of whom are financed by firms in Ciudad Bolívar. If there is a boom going on, these buyers arrive with thousands of bolívars in cash, which is usually in an attaché case chained to their wrist. Once at the boom camp, a buyer sets up a stand with scales and a magnifying eyeglass and awaits the miner. As one buyer, a Lebanese, confided to me, the whole game for the buyer is to classify the diamonds into as low a category as possible, in order to manage a suitable profit margin. During a boom, many buyers are present and the miner can go from one to another if he does not like the price offered for his lot of diamonds. But if there is no boom, he will have to sell to the available local buyer, in order to meet expenses.

Diamonds fall into three categories: *talla*, the best class, are high-quality stones with no defects; *industrial*, the next lowest category, represents the bulk of Venezuelan production; *fondo*, the lowest category, is almost worthless. Stones are paid for according to size, quality, and condition (internal defects or surface scars diminish the value). While prices respond to world market fluctuations, the buyers on the Caroni are quick to point out that a drop in the world market price reaches the mines in twenty-four hours while a rise in the market may take up to fifteen or twenty days to reach the mines. The companies in New York and London simply send out orders to "buy more, buy more." The buyer, then, must be willing to pay just enough to get the miner to sell and just little enough to earn his 5 percent when he resells in Ciudad Bolívar.

Buyers who do not judge correctly will soon experience severe losses, and all of them have their ups and downs. When asked about the percentage gain on a transaction, one buyer had this to say: "Well, that depends a lot on the ability of the buyer and of the seller since there are diamonds with imperfections—containing carbon, badly scratched, or of wrong color. The most common color, the white, has the most value. But when there is a defect, not even the buyer really knows the value.

Ramon Peña is the most important diamond buyer and merchant in the vicinity of the Los Frijoles and Guacharaca mines. Although he owns a house in Ciudad Bolívar, he prefers the relaxed life style at Uriman.

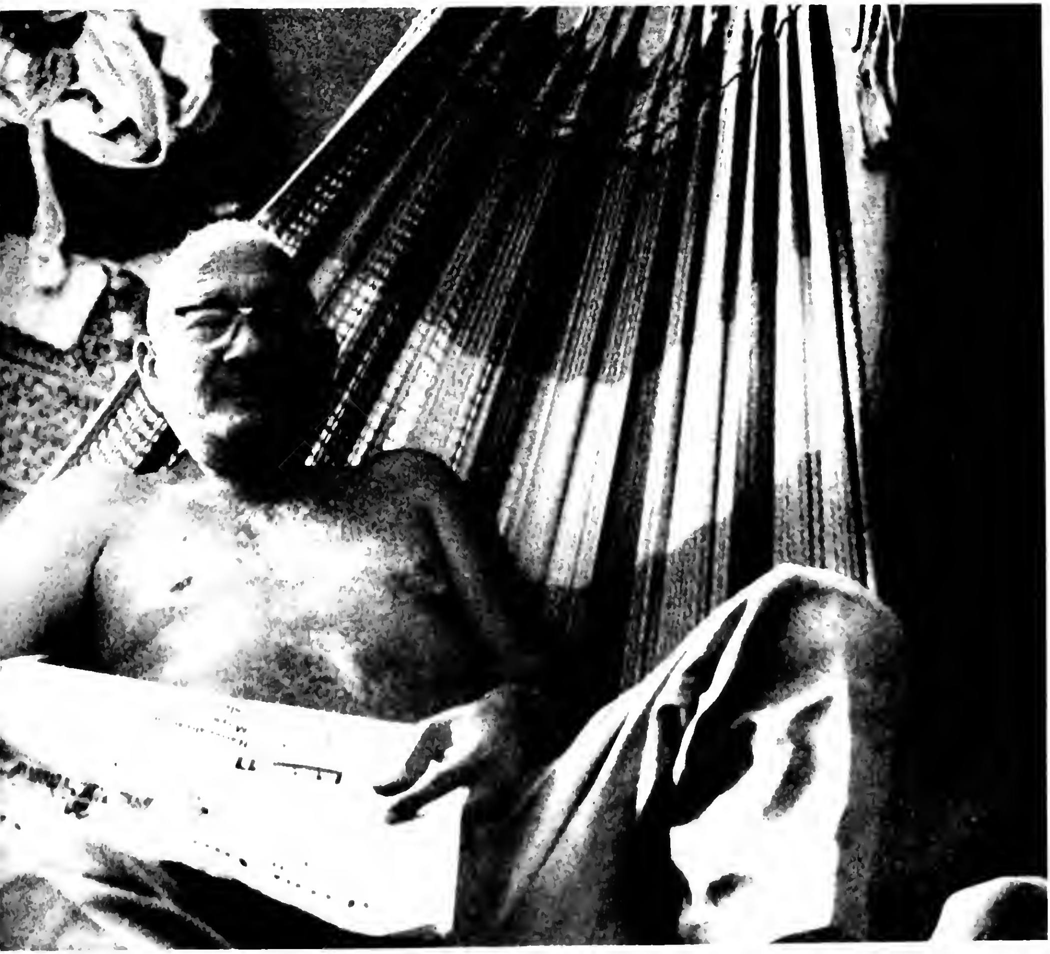
I have had times when I have lost 10,000 bolívars [$2,500] in one lot of diamonds. Sometimes I have gained 5, 10, and even 20 percent. But not all the time."

The next level of the chain, after the local buyer, is the intermediary in Ciudad Bolívar, where a number of small firms buy diamonds for export. Some firms are one-man operations; others consist of two or three partners, working with their own capital or with that of foreign companies. One intermediary, for example, is a representative of a Belgian firm. He has his group of agents, who buy diamonds in the mines for him. He gives them their percentage and then exports the diamonds to Belgium. He also buys directly.

The local buyer who only resells within Venezuela pays for a permit from the *consejo municipal* of the district he buys in. The exporter, however, must pay a 3 percent tax on the market value of all diamonds he exports. At the Ministry of Mines and Hydrocarbons, officials weigh and calculate the value of the diamonds, give the exporter a form that indicates the amount of his tax, and send him to the bank to pay it.

From the miner's point of view, the constraints of the market are just the price one must pay for going where one wills or where the action is. Some complain that diamond price rises are much slower to reach the mines than are drops in the value of their diamonds. They know full well the disparity between the prices of food and clothing in Ciudad Bolívar and those at Uriman or the mine. And they know that gradually the lands of the upper Caroni and similar areas are being consolidated into concessions. But the miners will hang on as long as they can in small pockets such as those at Los Frijoles. Many of them left home so long ago that there is no place to which they could return, even if they could afford to get back.

The process of consolidation will gradually overtake these independent miners, as the shifting mining frontier is transformed into an assemblage of extractive industries manned by the employees of huge national and multinational firms. The chain of market exploitation will be merged into the vertical structure of the modern corporation, and the free-lance miner will become a wage-laborer, insofar as he survives at all. □



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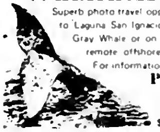

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Celestial Events

by Thomas D. Nicholson

Sun and Moon During December, the sun moves east through the stars of Ophiuchus and Sagittarius into the most southerly part of the ecliptic. It's low, short diurnal path brings short days and long nights to the Northern Hemisphere. The earliest sunset of the year occurs on December 8, the winter solstice (shortest day of the year) occurs on December 22, and the latest sunrise on January 4.

The moon illuminates the sky from dusk to dawn at the beginning of December but then quickly moves into the morning sky. The evening moon shows up again about the 22nd and remains until the first week of January. Full moon is on December 3, last-quarter on the 11th, new moon on the 19th, and first-quarter on the 26th. The next full moon will be on January 2, last-quarter on January 10, and new moon on January 17.

Stars and Planets The moon occults a bright star or planet five times in December and again five times in January, but only the occultations of Aldebaran on December 30 and January 26 are visible from North America.

The choice for the "Christmas Star" this year must fall between Venus, which becomes visible as a bright evening star, and the configuration of Jupiter, Mars, and Saturn in the sky near Regulus, the bright star of Leo. Technically, Venus is the only planet in the December evening sky (except for Neptune during the first two weeks). It becomes visible low in the west-southwest soon after sundown, setting shortly after dark. Jupiter, Mars, and Saturn are all morning stars, but rise well before midnight. The best show can be seen at about dawn, when very bright Jupiter is high in the south, rapidly brightening Mars is close by, Regulus is to its right, and Saturn to its left. The moon will also be in the vicinity from December 9 to 12. Unfortunately, none of this month's bright planets is placed where it can appear on the Star Map.

December 3: The moon is near the star Aldebaran tonight.

December 7: Mercury is at greatest westerly elongation, well placed for viewing as a morning star. Look for it low in the east after dawn during the first two weeks of the month.

December 9–12: The waning moon passes Regulus, Mars, Jupiter, and Saturn in succession. It is nearest Regulus on the 9th, Mars and Jupiter on the night of the 10th, and Saturn on the 11th.

December 13: Mars and Jupiter are in conjunction. Mars moves from right to left past Jupiter, but the two will remain close for several months.

December 14: The Geminid meteor shower (50 per hour) reaches maximum.

December 21: The crescent moon is near Venus tonight.

December 22: Solstice. Winter begins at 6:10 A.M., EST.

December 27: Jupiter begins its retrograde (westerly) motion.

December 30: The moon occults Aldebaran about 10:00 P.M., EST, visible in the eastern, southeastern, and southern United States

January 5–9: The moon again passes close to Regulus, Jupiter, Mars, and Saturn. It will be nearest Regulus on the 5th, Jupiter and Mars on the night of the 6th, and Saturn on the 7th and 8th.

January 17: Mars begins its retrograde motion, taking it closer to Jupiter and Regulus during the months ahead. The planet is now brightening very rapidly.

☆ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:20 P.M. on December 1; 10:20 P.M. on December 15; 9:20 P.M. on December 31; and 8:20 P.M. on January 15; but it can be used for an hour before and after those times.

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Observing Geese

THE YEAR OF THE GREYLAG GOOSE, by Konrad Lorenz. *Harcourt Brace Jovanovich, Inc., $25.00; 199 pp., illus.*

The Year of the Greylag Goose, a large-format book with text by Konrad Lorenz and photography by Sybille and Klaus Kalas, is meant to adorn the living room coffee table, where it may be thumbed through at leisure, not to be tucked away on the shelf of a library. The pictures, largely the work of Sybille Kalas, are beautiful in themselves and remarkably illustrative of the behavior and habitat of the graylag goose, which has been extensively studied by Lorenz and his coworkers for many years. As Lorenz indicates in his postscript, "The real story in this book is told by the photographs," and this is just as well, for certain aspects of the text are disturbing even when one realizes that this is not intended to be a scientific document, but a lighthearted and enjoyable story for the lay person with some interest in nature.

It is amazing how instructive first-class nature photography can be. Words could not possibly describe the technique geese use in landing as well as the photographs that illustrate this behavior. Courtship, mating, aggressive behavior, parental care, and the behavior of goslings from hatching to first flight are all clearly documented in excellent pictures.

In all probability, many readers will open this book, admire the photographs, read the fairly extensive legends accompanying each one, and hardly glance at the text. This is how most people respond to large books with many pictures. But a careful reading of the text leaves me with mixed emotions. There is, of course, admiration for the extensive knowledge Lorenz has acquired of the biology of these birds, for his obvious affection for his subjects, for the dedication that he and his associates have toward their work, for their love of nature and its beauty. All of these messages are clear in both text and pictures.

But there is also the story of Susanne-Elisabeth Breit and Janos Frohlich; the subsequent "unfaithfulness" of Susanne and her "passion" for Ado, followed by her death and Ado's "dumbstruck" grief. Then Ado comes to adore Selma, who already has a husband, Gurnemanz, and three youngsters. How did this soap opera get into a book about geese? But this is not a soap opera, and the characters in this story are *geese!* According to Lorenz, "pair formation ('marriage') among greylag geese follows exactly the same course as with ourselves" and "geese possess a veritably human capacity for grief." He feels that these statements are objective, not anthropomorphic. Others would disagree and describe the behavior in less human terms than love, hate, friendship, seduction. It is

by Madeline L. Cooper

not particularly edifying to talk about a "loveless copulatory relationship," an "unloved mistress," and a "ménage à trois" when describing reproductive behavior of geese.

The latter portion of the book describes the raising of geese—from the time they hatch until maturity—by human caretakers. Geese raised in this manner are very tame, allowing the caretaker to approach closely and make detailed behavioral observations that would not be possible with wild birds.

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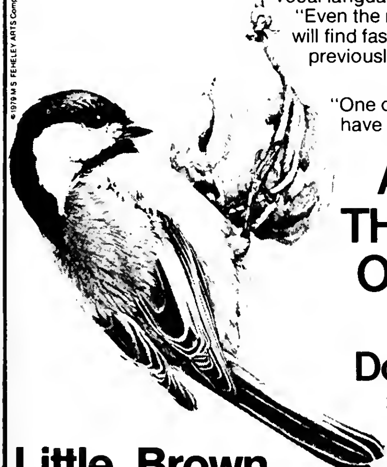

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Being a human foster parent to goslings is a time-consuming, arduous task. Lorenz's group have been perfecting their technique for many years, and they are quite successful although he notes that human-raised geese tend to have more accidents when learning to fly than do those geese raised by their natural parents.

Lorenz describes ethology as behavioral research based on the description of behavior patterns. What is the advantage of formulating these descriptions in terms of human society? Why try to make geese into little people?

Lorenz makes disparaging remarks about those who use experimental rather than purely descriptive techniques to study behavior. Yet his technique of raising young geese away from their parents is in itself an experimental procedure.

Madeline L. Cooper is a research associate in the Department of Animal Behavior at the American Museum of Natural History and the Department of Psychology, Barnard College, Columbia University.

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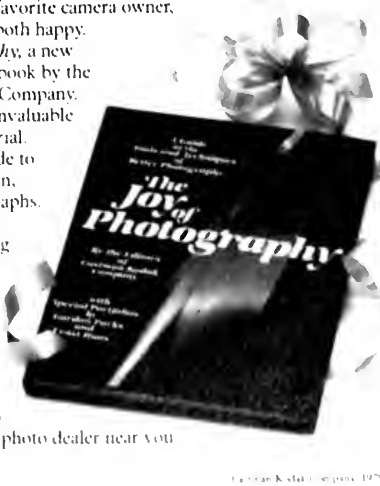

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How Constant Is the Sun?

Possible small variations in solar radiation have been measured but whether there is significant long-term change is still an open question

Our dependence on the sun for daily light and heat is so obvious a fact of our existence that it is often forgotten. In truth we owe much more than light and heat to this one star: all our food, through a chain of life that begins in simple plants and aquatic forms; the oxygen we breathe (replenished by photosynthesis in plants); and nearly all the energy we have ever used. In harnessing wind and water power, we reap the solar energy that drives the atmosphere and cycles the water from oceans to air; in burning wood or coal or petroleum, we are harvesting the sunlight that fell upon the earth in ages past.

A realization of our utter dependence on this burning ball of gas, 93 million miles away, leads to old and eminent questions: Is the sun a constant fire? How do its outputs vary? And how susceptible are we to known or suspected variations? Our fate would be dire indeed were the sun to go out altogether or loom suddenly to explosive, nova brightness. But what of smaller, more probable changes in the sun's total input of light and heat to the earth—the so-called solar constant? What results from more subtle changes in the ultraviolet radiation from the sun or its output of atomic particles or its magnetic fields? Could it be that terrestrial weather, for example, is controlled by varying inputs from the sun?

In fact, the sun is the engine that drives our atmosphere, creating winds and rain and clouds and snow. Changes—even minor ones—in the sun's inputs to the earth could alter atmospheric temperature, circulation, and composition. These solar-induced changes, if small, could pass unrecognized in the crowd of other intrinsic variables of the atmosphere. But if they were persistent and consistently of one sort, their cumulative effect could alter the long-term average of the weather, called climate, and through climatic change, bend the path of human progress. Present mathematical models of global climate show that a decrease of one percent in the total radiation from the sun would lower the average temperature of the earth by one or two degrees Celsius—enough to bring about a little ice age of the sort that seems to have gripped Europe and North America throughout the seventeenth and eighteenth centuries. Similar numerical simulations suggest that a change of but 0.1 percent in solar flux, if continued long enough, could bring about climatic changes of significant social and economic impact. And a decrease of 10 percent could be globally disastrous, inducing major glaciation and perhaps an ice-covered earth, which would thaw only after a far greater and less likely increase of about 50 percent.

Variations in weather and climate, however, do not necessarily incriminate the sun. It is certainly the engine that drives the earth's atmosphere, but there are many other factors, including ocean temperature and circulation, cloud cover, and polar ice, nearly all of which can vary on their own. The complex atmosphere of the earth seems capable of producing variable weather and interesting climate even with a sun of perfect constancy. The succession of day and night, the march of the sea-

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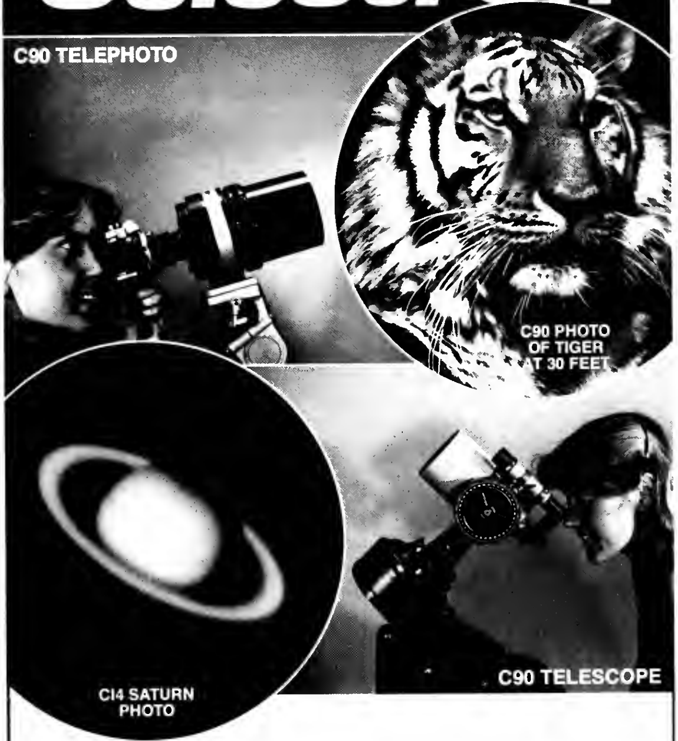

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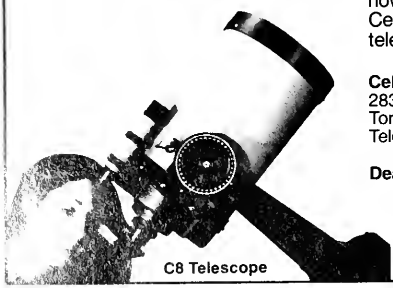

sons, and now, as seems likely, the recurrence of the awesome ice ages, can be explained by the movements and orientation of the earth in its orbit, with no need for any solar variability at all. Shorter excursions of climate and the vagaries of daily, local weather could follow from wholly random variations or because of any one of several competing effects that come from within the atmosphere itself.

Thus the question of the sun's role in bringing on changes in weather or climate hinges first on whether it is a variable star.

We know, of course, that it is. With the first telescopes, early in the seventeenth century, came the realization that the sun, like all else in nature, is ever changing. On its bright surface were small dark spots whose positions and number changed from day to day. The concept of a blemished sun was at first resisted by Western thought and theology, although it was soon accommodated by the rationalization that the dark spots were only clouds that floated across an otherwise perfect object. Today we know that sunspots are deeply rooted disturbances; they mark the places where intense magnetic fields break through the solar surface. These varying magnetic fields, thousands of times stronger than that of the earth, produce other, dynamic changes on the sun and identify it as a magnetically variable star. Although sunspots appear small, their average size is about that of the earth and the patterns of magnetic field with which they are associated reach far beyond their boundaries.

Since the middle of the last century we have also known that the sun produces sunspots in a fairly regular cycle of about eleven years, during which time their number, counted on any day, rises from none or almost none, to as many as several hundred, and then back to zero. Most other features of solar variability, such as the occurrence of solar flares, or prominences, or transient disturbances in the corona of the sun, seem to follow this same rule. Thus the eleven-year sunspot cycle has come to be synonymous with solar variability and is probably the best-known feature of the sun. The physical reasons for the occurrence of sunspots and their cyclic production are still not clearly known, although many characteristics of the cycle can be adequately explained as a product of interaction between magnetic fields within the sun and the nature of solar

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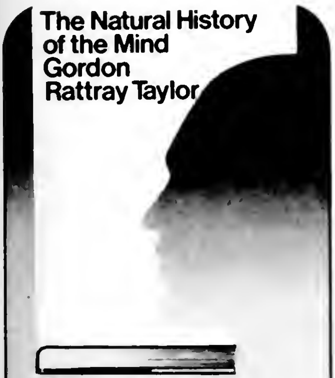

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surface rotation, through a mechanism known as the solar dynamo. Nevertheless, the extent to which sunspots or the processes that modulate them alter the total radiative output of the sun is not yet clear.

Far more effort has been spent in searches for direct terrestrial implications of sunspots and the sunspot cycle than has ever been given to their physical explanation. These efforts followed originally from the assumption that these dark, cooler features should block some of the radiation from the sun and thus produce a diminution of solar heat at the earth. References to such effects are widespread and are found as early as the seventeenth-century writing of Milton and in the works of Jonathan Swift. Whether sunspots actually decrease the total light from the sun has never been answered with exactitude, although we can now put limits on the effect that make it very, very small. At the maximum of the cycle, when the sun is most spotted, sunspots could reduce the total sunlight by about 0.01 percent. It seems more likely that this small effect is compensated for, or overwhelmed by, the increased radiation from nearby, brighter areas.

Much of the attention in the past to the practical influence of sunspots can be attributed to the almost hypnotic attraction of cyclic phenomena and the hope of finding simple keys to the prediction of future events. The apparent regularity and presumed cosmic significance of these easily seen phenomena drew a steady stream of determined attempts to link the ups and downs of sunspot numbers with similar cyclic features in weather, agriculture, economics, health, and human behavior.

Scientific and popular efforts to identify a weather connection began in earnest in about 1850, following the discovery of the sunspot cycle. At first the relationship seemed to work. The 1870s, 1880s, and 1890s were characterized by a flurry of scientific papers purporting to have found important connections between the eleven-year sunspot cycle and the weather—as measured in monsoons in India, rainfall in Sri Lanka (Ceylon), temperature in Scotland, or the depth of the Thames, the Elbe, or the Nile. A new day had dawned, some said, in which astronomy, through weather prediction, would allow us to anticipate and thus conquer problems that had long plagued mankind. "The riddle of the probable times of occurrence of Indian

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famines," announced solar astronomer Sir Norman Lockyer in 1900, "has now been read, and they can be for the future accurately predicted." The prediction, we need hardly explain, lay in a pattern of recurrence that, according to Lockyer's researches, seemed to follow the ups and downs of the sunspot cycle.

And then the bubble burst. When examined more critically, the simple connections vanished one by one or faded in the harsher light of longer records. By and large, scientists came to recognize these early, simplistic relationships as accidental coincidences in limited records and examples of what Nobel laureate Irving Langmuir called "pathological science," in which our own desire to find a certain result influences what we do or do not see.

More recent knowledge of both the sun and the weather makes simple cause-and-effect chains either unlikely or masks them with other, possibly random variations. They could still be important in understanding our atmosphere. But to find real solar influences and to make practical use of them in prediction, we need first to know what to look for and when and where. This requires that we know not just the sunspot number or the solar constant but what all the variable outputs of the sun are and how they might affect our atmosphere, from top to bottom.

We know that the ultraviolet and X-ray radiations from the sun vary appreciably from day to day and that the sun's outward flow of atomic particles and magnetic fields is constantly changing. These are minor perturbations in the total budget of solar energy we receive, and in each case affect the earth directly only at the topmost layers of the atmosphere. Perhaps these influences reach down to the lowest levels of the atmosphere. But if these upper atmosphere effects of solar variability are to influence the weather in the denser troposphere far below, we need to find a way for the tail to wag the dog. Before we can hope to identify such subtle effects we need first to examine the coarser, potentially more important question of whether the total solar radiation, or solar constant, varies from day to day or year to year.

Similar reasoning led Lockyer and other astronomers and meteorologists of the last century to initiate a program to answer this fundamental question. In the 1870s instruments were developed, and in the 1880s a British program was begun to monitor the total

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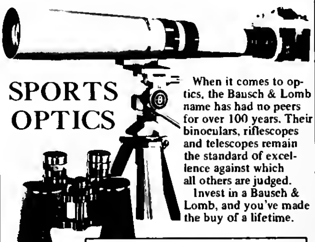

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radiative flux from the sun in order to determine whether and how it varied. Astronomers wish they had kept at it. Instead their efforts lasted but a few years and then died owing to lack of interest and funds and the difficulty of correcting the measurements for the varying transparency of the atmosphere. The latter is a serious problem. At the surface of the earth, in India, where the British measurements of 1880 were started, the murky, changing atmosphere transmits at most 60 percent of the sunlight, requiring a theoretical correction for the remaining 40 percent and putting severe constraints on final accuracy.

When British efforts stalled, the challenge was taken up in the United States by Samuel Pierpont Langley, an American astronomer of broad abilities who was later to become known as a pioneer of aviation. At the time, Langley was involved in observations of the sun and solar infrared radiation at the Allegheny Observatory in Pittsburgh. He recognized the problem of atmospheric transmission in measuring the solar constant and worked hard to minimize it. First, he expanded the concept of the measurement to include the spectral distribution of sunlight—quantitative measurements of how much solar energy reaches us in each small region of the spectrum. In this way it was possible to correct more accurately for atmospheric absorption. Next, Langley carried his apparatus as high in the atmosphere as he could go: in 1878 to Pike's Peak and in 1881 to Mount Whitney in California.

When in 1887 Langley accepted a new position as secretary (director) of the Smithsonian Institution he organized an Astrophysical Observatory in which the solar constant program played a major part. To help him, Langley hired young Charles Greeley Abbot in 1896. It was a good choice, for Abbot, an astronomer, stayed with the solar constant measurements at the Smithsonian for more than fifty years, until 1957, when measurements were at last discontinued. His own interest in the solar constant and spectral data never flagged, and when he died in 1973 at 101, Abbot was still at work on their interpretation.

Under Abbot's direction, measurements of the solar constant and spectral radiance were made every possible day at an evolving chain of mountaintop stations around the world—in California, Arizona, New Mexico, North Carolina, Egypt, Algeria, and South

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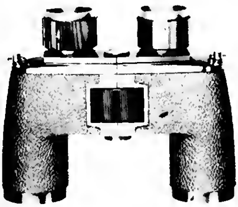

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Africa—and at sea-level stations in Miami and Washington, D.C. During this extended measurement program, surely the longest in the history of astronomy, Abbot became convinced that he had found real variations in the solar constant. The variations he reported were between 0.1 percent and 1 percent and Abbot believed they recurred in cycles, the longest of which was about two sunspot cycles, or twenty-two years. Critics, during and since, pointed out that the fluctuations found by Abbot at one station were not confirmed by similar data from another and thus should be attributed to changes in the atmosphere of the earth. To many, Abbot's long vigil served chiefly to demonstrate that the solar constant *was* constant to within our ability to measure it from the ground.

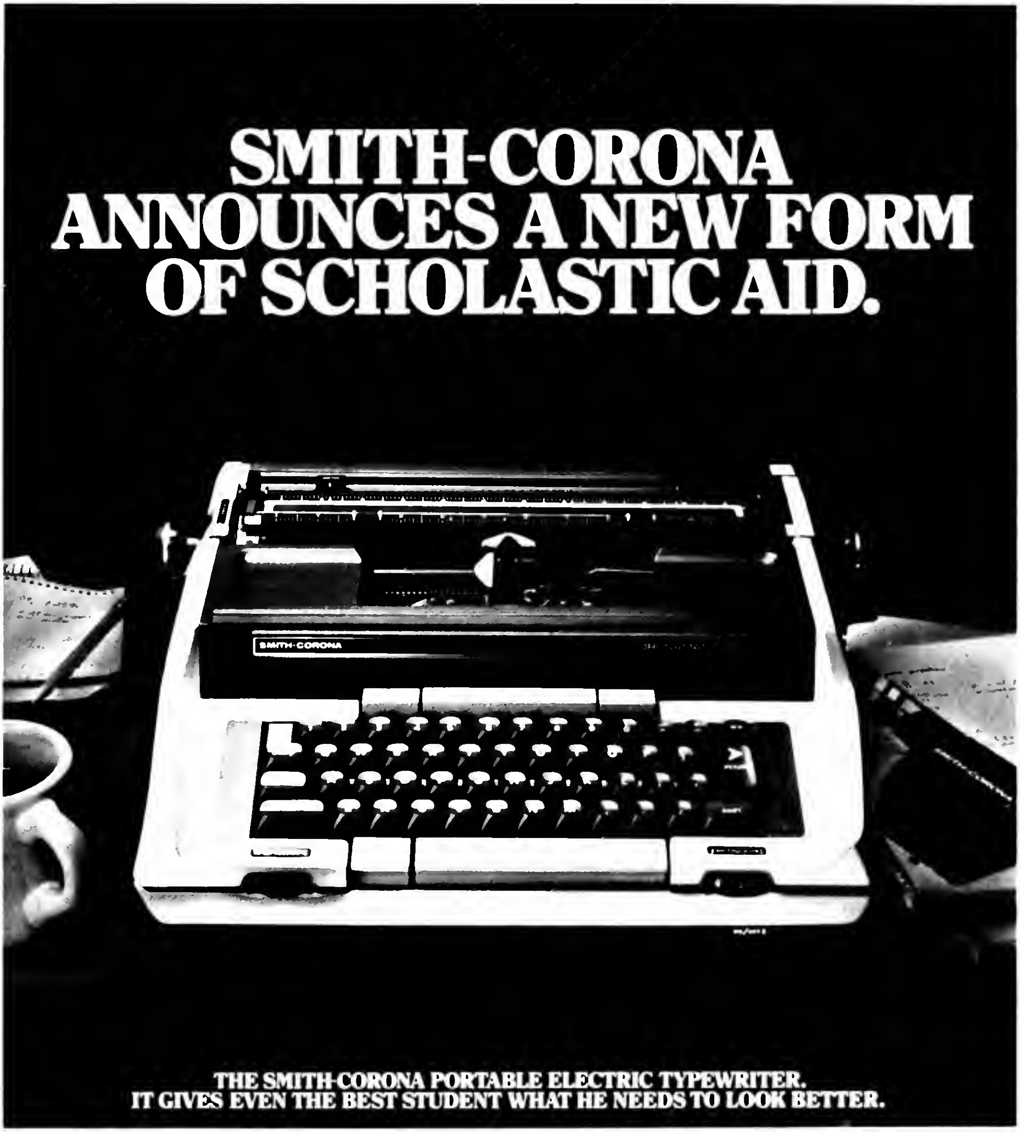
With the age of rockets and satellites, new efforts were mounted to measure the solar constant from above the atmosphere, where the measurement of intrinsic solar variability should be possible. In the late 1960s a number of these measurements were made from rockets, spacecraft, balloons, and high-altitude aircraft. They brought a new appreciation of the difficulty of the problem, for the values reported were not in close agreement. Was this a measure of the inherent accuracy of any one experiment or was the scatter in these modern measurements an indication of temporal variability of the solar constant?

To answer this a second generation of spaceborne programs was started, aimed not so much at absolute accuracy as at detecting relative, day-to-day or month-to-month trends in the solar constant. The first was flown on the *Mariner VI* and *VII* spacecraft, which provided data for about a half year in 1969. More promising experiments were placed on *Nimbus 6* (launched in 1975) and *Nimbus 7* (1978), both of which are still in operation. Data from both these series are less than conclusive because of the significant corrections required for spacecraft orientation and pointing and for known or suspected effects of instrument degradation. After correction for these effects, the 1969 *Mariner* data showed possible variations at the 0.1 percent level; the *Nimbus* results so far available rule out changes greater than 0.2 percent but leave open the possibility of real change of a smaller amount. Neither series can answer the question of possible long-term change. Thus the question of climatically significant, short- or long-term changes in the solar constant remains unanswered.

But other results continue to suggest the reality of real changes in the solar constant. Reanalysis of Abbot's data has shown a minute variability of the solar constant that follows the occurrence of bright regions, or plages, on the sun. Not long ago, an astronomer at the Kitt Peak National Observatory reported a possible change in the temperature of the sun based on his analysis of highly sensitive spectral lines in the photospheric spectrum. This could in turn represent a real change in the solar constant, at the level of several tenths of a percent in a few years. More recently, two researchers at Denver University reported that balloon flights made with the same instrument in 1968 and 1978 to measure the solar constant indicated a real increase of 0.4 percent during this time. And last autumn, rocket flights made to cross-calibrate satellite-borne solar constant detectors suggested a change of about the same amount when referred to earlier, absolute measurements.

Because of the importance of measurements of the solar constant and the solar spectrum to studies of both the climate and solar physics, several national scientific panels have urged a dedicated national program to monitor these crucial parameters for a period long enough to answer the question clearly. I feel that it will take a program of at least two sunspot cycles, or twenty-two years, and that measurements will be required from space and ground. The effort need not be expensive but longevity must be insured if we are to avoid the fate of the British attempts of a century ago. Such a program will require new technology in developing measurement standards and careful planning to insure optimum short-term and long-term results. Whether the answers found tell of major changes, minor changes, or no changes at all, the results will surely be of fundamental importance to astrophysics, to atmospheric science, and perhaps to human welfare. A definitive measurement of the degree of variability of the various outputs of the sun would surely be the biggest step yet taken toward answering the age-old question of the sun's influence on weather and climate.

John A. Eddy is a senior scientist on the staff of the High Altitude Observatory in Boulder, Colorado.



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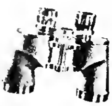

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Additional Reading

Sticklebacks (p.32)

Part one of *The Biology of the Sticklebacks*, by Robin J. Wootton (New York: Academic Press, 1977), discusses the morphology, anatomy, distribution, development, feeding, parasites and predators, and reproduction of threespine sticklebacks. Part two introduces other sticklebacks and is followed by a 24-page bibliography. "Threespine Stickleback *Gasterosteus aculeatus Linnaeus*" is a short entry, pages 665-68, in *Freshwater Fishes of Canada*, by W. B. Scott and E. J. Crossman (Ottawa: Fisheries Research Board of Canada, 1973). *Modes of Reproduction in Fishes*, by Charles M. Breder, Jr., and Donn E. Rosen (Garden City: Natural History Press, 1966), has a short chapter, with many references, on sticklebacks.

Alfalfa Weevils (p.36)

R. J. Dysart and William H. Day's *Release and Recovery of Introduced Parasites of the Alfalfa Weevil in Eastern North America* (U.S.D.A. *A.R.S. Production Research Report 167*) is a report on the original research, done in New Jersey, on the use of wasps to control alfalfa weevils. *Biological Control by Natural Enemies*, by Paul DeBach (New York: Cambridge University Press, 1974), and *Beneficial Insects*, by Lester A. Swan (New York: Harper and Row, 1964), are popular introductions to the subject. *Biological Control*, by R. van den Bosch and P. S. Messenger (New York: Intext Educational Publishers, 1973), is an introductory textbook that treats insect ecology, population control, and famous cases and techniques of biological control. Another introductory-level work is R. R. Askew's *Parasitic Insects* (New York: American Elsevier Publishing Co., 1971). In *The World of an Insect* (New York: McGraw-Hill Book Co., 1967), Rémy Chauvin combines information on ecology, microclimate, and population numbers with the history of entomological discoveries. Two compilations are *Proceedings of the Summer Institute on Biological Control of Plant Insects and Diseases*, edited by F. G. Maxwell and F. A. Harris (Jackson: University Press of Mississippi, 1974), and *Theory and Practice of Biological Control*, edited by C. B. Huffaker and P. S. Messenger (New York: Academic Press, 1977).

Juggling (p.44)

Many juggling books, if not available at libraries, can be obtained through magic-supply shops. *Circus Techniques*, by Hovey Burgess (New York: Thomas Y. Crowell Co., 1977), discusses three levels of difficulty in juggling, equilibristics, and vaulting. *The Art of Juggling*, by Ken Benge (Mountain View: World Publications, 1977), gives instructions for learning to juggle. Other how-to books are *Want to Be a Juggler?* by George De Mott (Tulsa: Montandon Magic, 1962); *Juggling Made Easy*, by Rudolf Dittrich (Hollywood: Wilshire Book Co., 1967); and *Manual of Juggling*, by Max Holden (Chicago: Ireland Magic Co., 1947). Benge's *3 Ball Juggling* (Chicago: Magic Inc., 1972) is about one kind of juggling; *The Juggling Book*, by Carlo (New York: Random House, 1974), is more general.

Mona Island Iguana (p.56)

The World of Reptiles, by Angus

Bellairs and Richard Carrington (New York: American Elsevier Publishing Co., 1966), is a general introduction to the classification, physiology, and behavior of living reptiles of the world. Bellairs also discusses the anatomy, behavior, and evolution of reptiles in a two-volume work, *The Life of Reptiles* (New York: Universe Books, 1970). Although somewhat outdated, Hobart M. Smith's *Handbook of Lizards of the United States and of Canada* (Ithaca: Comstock Publishing Co., 1946), is a useful key to North American lizards, with notes on ecology and behavior. Two books in the Peterson Field Guide Series, Roger Conant's *A Field Guide to Reptiles and Amphibians of Eastern and Central North America*, second edition (Boston: Houghton Mifflin Co., 1975), and Robert Stebbin's *A Field Guide to Western Reptiles and Amphibians* (Boston: Houghton Mifflin Co., 1966), are more up to date. *Biology of the Reptilia*, volume 7, edited by Carl Gans and Donald W. Tinkle (New York: Academic Press, 1977), contains eight scientific papers, which treat such topics as senses, learning, the reptile as an organism, and how reptiles use the environment and interact with each other. An earlier set of scientific papers on population ecology, social behavior, and physiological ecology is *Lizard Ecology: A Symposium*, edited by William W. Milstead (Columbia: University of Missouri Press, 1967). For a discussion of adaptations of plants and animals for island life see *Island Biology*, by Sherwin Carlquist (New York: Columbia University Press, 1978).

Katharine D'Agosta

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At the Museum

In his memoirs, Adm. Robert E. Peary wrote: "Never have I had the terrific majesty of the force of gravity and the meaning of the terms 'momentum' and 'inertia' so powerfully brought home to me as in handling this mountain of iron." The "mountain" Peary was referring to is a fragment of the Cape York meteorite, called the Ahnighito, or Tent—68,085 pounds of irregularly shaped nickel iron. It is the largest meteoritic fragment that has been recovered and put on display.

Early in September, the weight of the Ahnighito meteorite once again made itself felt, this time to a group of workmen who were to move it from the Hayden Planetarium, where it had been on display since 1935, to a new resting place in the Arthur Ross Hall of Meteorites, now under construction. During the first week of the operation, workmen knocked a ten-by-twelve-foot hole in the west wall of the Planetarium and transported the Ahnighito and another piece of the Cape York shower, the three-ton Woman, by crane and flatbed truck to 78th Street and Columbus Avenue. On the morning of September 13, the Ahnighito and Woman were moved into their new abode. Martin Prinz, chairman of the Department of Mineral Sciences and a specialist on meteorites, watched the activity with a knot of curators.

"The Cape York meteorite landed a few thousand years ago in Greenland," he explained. "I would say that the original body came in at about nine miles per second, or about 33,000 miles per hour. That's the average speed of a meteor when it hits our upper atmosphere. It weighed perhaps two hundred tons and broke up in the turbulence as it came down. We've recovered about fifty-eight tons of it—Ahnighito is the biggest piece—but a lot more is probably in the ocean. I figure that when it landed it must have released the energy of 6,000 tons of TNT. It is eight times denser than water. A cubic foot would weigh 500 pounds."

One invertebrate paleontologist asked Prinz if meteorites rusted.

"Do they rust? In a million years, nothing will be left of that thing—it will have rusted into oblivion. You know, I would love to see it sandblasted and all shined up. That would be an impressive sight."

The future Hall of Meteorites is currently a storage area for discarded exhibits. A stuffed dugong and a horse skeleton gazed imperturbably on the workmen as they toiled about the dark mass, which rested on a steel platform, which in turn rested on foot-thick steel rollers set on two girders. Massive wooden beams shored up the floor, and the six steel columns that will support Ahnighito descended through jagged holes in the floor to the basement, where they were bolted to the floor and set in concrete. At the top of each support, members of the Museum's metal shop had welded their initials and the date, "79."

The Cape York shower probably fell on a thick ice sheet, and as the ice retreated, the fragments were left *in situ*. Humans, migrating east across the northern tundra, arrived in Greenland about A.D. 1000. Their discovery of the meteorites precipitated a premature iron age—Eskimo knocked off flakes from at least four of the fragments and cold hammered them into cutting edges for their knives and spears. The Eskimo must have traded the iron among themselves since bits of Cape York iron have been found in midden heaps as far as 300 miles to the southwest. Both Ahnighito and Woman reveal the extensive hammering of their surfaces that took place over the centuries.

In 1818, while searching for the Northwest Passage, Sir John Ross came across a group of 350 Eskimo using iron tools. They told Ross of an "iron mountain" somewhere in Melville Bay. Although Ross did not find the iron mountain, he did bring back several tools that were analyzed and found to be rich in nickel, indicating a meteoritic origin. Later, expeditions of various nations tried to locate the source of the iron, but by then the Eskimo were being supplied with iron tools from passing ships and had forgotten where it was. Finally, in 1894, an Eskimo led Admiral Peary to a place called Saveruluk and showed him two chunks of iron, later named Woman and Dog, weighing three tons and one ton, respectively. Apparently the Eskimo had been hammering pieces from the two meteorites for centuries; within a radius of about thirty-three feet, thousands of broken basaltic hammers littered the ground. Six miles to the

Paper Tigers

On Monday, November 19, the annual Origami Holiday Tree was unveiled in the Roosevelt Rotunda before a large group of Museum employees and volunteers. The tree, bigger than last year's, is hung with hundreds of new and improved folds—from horseshoe crabs, tarantula spiders, and snapping dinosaur heads to pterodactyls, cockroaches (several species), and tigers. Visitors may view the Origami Tree through the first week in January.

Spanish Textiles

The early Spanish settlers along the Rio Grande brought with them a body of weaving traditions—distinct from Navajo and Pueblo traditions—that produced woven blankets, serapes, and embroidery with characteristic designs and motifs. *Southwest Weaving: The Spanish Tradition*, a traveling exhibition organized by the Museum of International Folk Art in Santa Fe, will open in the Akeley Gallery on December 14.

Family Films

The Department of Education is presenting a series of short live-action and animated films on a variety of topics. Highlights include *Taleb and His Lamb*, about a Bedouin boy whose father insists on selling his pet lamb, and *Maria of the Pueblos*, a documentary about the well-known Pueblo Indian who revived the ancient art of pottery. These free films will be shown on December 27, 28, and 29 at 1:30 and 3:00 P.M. in the Auditorium.

American Rocks

A collection of representative American gemstone jewelry is on display in the Hall of Minerals and Gems until January 31. The pieces are made exclusively from native gems and precious metals, ranging from Maine tourmalines to Montana sapphires and Dakota gold.

Nature Faking

Techniques for creating natural history exhibits have evolved since the turn of the century. Animals used to be "stuffed"; now preparators build a clay sculpture on the actual skeleton and stretch the skin over a cast of the model. Leaves and tendrils were once made from paper and wax; now they are formed from cellulose acetate in a vacuum mold. For the December Members' Program, December 12 at 7:30 P.M. in the Auditorium, Raymond de Lucia, chief preparator at the Museum for many years, will screen a film and discuss the tricks of the trade used by exhibit makers. *Creating a Natural History Exhibit* is free to all Members; nonmembers may purchase tickets for $3.00 at the door.

African Dance

Dinizulu and His African Dancers, Drummers, and Singers will present an afternoon of traditional dance and music from Africa on Sunday, December 2, at 2:00 P.M. in the Auditorium. Dances include the Egungun, a secret society dance from the Anagos, Nigeria, and the Gumboot, a dance of South African miners. There is no admission charge to the program.

south, Peary discovered a third source of Eskimo iron, a partially exposed mass with a great deal more covered by earth. This was the Ahnighito, or Tent. The Eskimo told Peary that the three meteorites had been a sewing woman and her dog who were thrown out of heaven, along with their tent, by the evil spirit Tornarsuk. The evidence is strong that the Eskimo made up the "legend," knowing that Peary believed the iron had fallen from the sky. Peary later wrote that the Eskimo had witnessed the Cape York shower.

Peary shipped the Dog and Woman to New York in 1895 and returned the next summer to excavate Ahnighito. He built a cart, railroad tracks, and a bridge to transport it to his 307-ton vessel, the U.S.S. *Hope*. In the autumn of 1896, the *Hope* arrived at the Brooklyn Navy Yard in New York, where the Ahnighito promptly broke the fifty-ton floating crane that was to hoist it ashore. After a hundred-ton crane successfully completed the job, the Ahnighito was stored in the Yard, where it remained for nine years.

Mrs. Peary, acting as her husband's agent, wanted at least $60,000 for the three meteorites. She wrote in 1906 to Morris K. Jesup, president of the Museum: "The meteorites are all I have and I feel that I should make an effort to turn them into money and invest it so that my children will have something with which they can be educated and fitted to earn a living."

Despite her appeal, the impecunious Museum haggled over the price for years; finally, thirteen years after the meteorites had arrived in New York and three years after they had actually been delivered to the Museum, Mrs. Peary accepted a check for $40,000.

The delivery of the Ahnighito to the Museum in 1906 caused no little excitement. At the Navy Yard it was again loaded on a barge and floated up the East River to a dock on East 50th Street. A block-long line of fourteen teams of horses, accompanied by crowds of street children and curious onlookers, then hauled it across town and set it down in the Museum's 77th Street archway. It was later moved to the 81st Street side of the Museum, and in 1935, the Hayden Planetarium was built around it.

Visitors will be able to see the Ahnighito, Woman, and Dog in the fall of 1980, when the new Arthur Ross Hall of Meteorites is scheduled to open.

Douglas J. Preston

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The *Anser* Is a Goose

The question is what bird is suitable for a traditional Christmas meal

By mid-December, all serious Americans are asking themselves the question, What shall I serve for Christmas dinner? Some iconoclasts I know have opted for Chateaubriand or even lobster. Italian-Americans of a traditional sort prepare capon, elaborately stuffed. But for most people, the mainstream, colonial, Anglo-Saxon tradition dictates a big bird. And almost invariably, these days this means a turkey.

Turkeys are cheap, as cheap as any meat source. They are widely available, and the militant seeker after quality can find them freshly killed without waging a campaign at the butcher's. Connoisseurs, on the other hand, serve goose, which is equally traditional for Christmas. But goose is expensive, not universally marketed, and almost never sold unfrozen. Goose, a tastier fowl than turkey, takes a distant second to the gobbler in modern American Christmas celebrations.

This is exactly the reverse of the way things used to be. Goose was the preeminent Christmas bird in early America and in England, where the tradition of yuletide goose pies and roast goose began. To be more precise, in

...ffling for the Goose, *William Sidney Mount (1807–68)*

England goose was the customary bird and turkey was a special luxury. Tiny Tim and the other poor Cratchits made do, happily enough, with a goose in Dicken's *A Christmas Carol*:

There never was such a goose. Bob said he didn't believe there ever was such a goose cooked. Its tenderness and flavour, size and cheapness were the themes of universal admiration. Eked out by apple-sauce and mashed potatoes, it was a sufficient dinner for the whole family; indeed, as Mrs. Cratchit said with great delight (surveying one small atom of a bone upon the dish) they hadn't ate it all at last! Yet every one had had enough, and the youngest Cratchits in particular were steeped in sage and onion to the eyebrows!

Metropolitan Museum of Art, Gift of John D Crimmins 1897

Enough is as good as a feast, of course, but when Uncle Scrooge awakens from his threefold nightmare, brimming over with Christmas spirit, the first thing he does is buy the Cratchits a huge turkey. ("He never could have stood upon his legs, that bird. He would have snapped 'em short off in a minute, like sticks of sealing-wax.")

The lesson this teaches is that in Dickens's England, goose was cheap and turkey was dear. A similar state of affairs obtained in prerevolutionary China when Chiang Jung-feng was growing up on a farm outside Chengdu in the heart of Sichuan. "Geese and their eggs were usually cheaper than chickens because they were bigger," she told Ellen Schrecker when they were preparing *Mrs. Chiang's Szechwan Cookbook.*

In other places and times, geese have also been an ordinary feature of barnyard life, waddling reservoirs of fat, down, and estimable flesh. Since they can feed themselves almost entirely by grazing on inferior pastureland, they are simple and cheap to raise. They can be taught to herd sheep, and they also make good watchdogs. Geese will fiercely "goose" an intruder with their beaks or honk loudly in alarm when one approaches.

The ancient Egyptians kept geese. And the early Romans revered them from time immemorial, especially after the invasion of the Gauls in the fourth century B.C., when, Livy recounts, a nocturnal raiding party of barbarians eluded Rome's sentries and watchdogs, but did not succeed in overrunning the Capitoline because their stealth "did not deceive the geese that were kept there as sacred birds of Juno and never eaten even when food was most scarce."

In Christian Europe, geese also have a religious significance, being associated with Saint Michael's Day, or Michaelmas, September 29, one of the so-called quarter-days when tenants traditionally paid a fourth of their annual rent. They also presented a goose to their landlords at the same time. As a result, Michaelmas is also known as Goose Day, and there are various old customs revolving around the consumption of the Michaelmas goose. Germans believed they could foretell the weather by close examination of its breastbone. In Ireland, not only was the Michaelmas goose said to ward off disease, but a goose pie was baked with a golden ring inside and whoever found the ring would marry well and early.

Goose Day came to the United States roughly 200 years ago, when a Pennsylvania Dutch farmer, Andrew Pontius, settled in Snyder County in the center of the state and hired a young British deserter from the king's navy as a tenant farmer. The tenant, one Archibald Hunter, arranged for his accounts to be settled on Michaelmas, and when the day rolled around, he surprised Pontius by arriving with a goose under his arm. So, according to this supposedly true story, began central Pennsylvania's Goose Day, a celebration that still thrives. In most other places, however, geese are rarely seen, even on working farms, although some people in exurbia keep geese as semi-pets. There were a few geese roaming a meadow in northern Maine where I stayed this August at a rural homestead that also accommodated a few horses and chickens picturesquely by the banks of a tidal river. It was hard to tell if the farmer lady was going to eat her backyard geese for Christmas, and I didn't have the heart to ask.

Geese are good at making themselves part of the family. They will come when called, untie your shoes, or take the valve cap off automobile tires. And, as ethologist Konrad Lorenz discovered, geese will attach themselves to a human being and make that person their "parent" if he or she is the first

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living thing they see upon hatching. When a graylag gosling (*Anser anser*) did this to Lorenz, the bird insisted on spending every waking moment with the scientist, making his life hectic for several months but also giving him a special chance to "relate" to a bird and subsequently to write a famous study of goose behavior.

Lorenz did little more than establish in a rigorous way what myriad goose girls and boys had learned over generations of "interaction" with their geese. In this country, as in Europe, until this century geese were raised by hand, a few at a time, for the family, on small farms. But as America's small farmers fled the land in droves and their farms were swallowed up by agribusiness and suburbia, barnyard geese disappeared from the land along with the yeomen who had bred them for their Christmas tables.

Mechanized agriculture did not step into the breach. In all of America, there are not enough geese in commercial production to make it worthwhile for the U.S. Department of Agriculture to publish figures for them in its annual compendium *Agricultural Statistics*. The same book counts almost 300 million American chickens and about 135 million turkeys. An unofficial but educated estimate of the size of the national goose slaughter runs to a mere 600,000.

The primary problem with geese in modern America is not that people traditionally have eaten them only at Christmas. Thirty years ago, the turkey was also a specialty bird, but Swift and Company and other major producers invested heavily in turkeys, learned to raise them in confinement as if they were hothouse tomatoes, and brought the price per pound down to a level so low it changed national eating habits, turning Scrooge's delicacy into every delicatessen's favorite bargain.

With geese, biology imposed a different destiny. "We tried confinement," says Wilbur Ramble, who runs the hatchery at Pietrus Foods, a large goose production company in Sleepy Eye, Minnesota. "The goose is a grazing bird. In confinement, the geese went down on their legs. Their feet had swelled up with infection from walking on wooden slats. They pecked so bad, they had to be debeaked so they wouldn't kill each other."

Geese need twice the space that turkeys do, as much space as a hog. Goslings are still put out to pasture, in huge, billowing flocks that sometimes number as many as 10,000. And they do well on nothing but grass and a modest grain supplement. But that is not enough to make them competitive with chickens as protein machines. A hen will lay more than 200 eggs in a season, while a good goose will not do better than 40. Moreover, 90 to 95 percent of chicken eggs hatch into chicks. Wilbur Ramble estimates that only 78 percent of his goose eggs hatch successfully.

Worst of all is the problem of pinfeathers. Geese get "pinny" three times during their maturation period, at roughly nine, sixteen, and twenty-two weeks of age. When the new feathers are just coming in, apparently as part of some vestigial genetic process preparing the plumage for a seasonal migration, the geese are virtually impossible to pluck. At least, they cannot be plucked cleanly enough to satisfy stringent Department of Agriculture inspection standards.

In most other countries, geese simply have the feathers removed. In the United States, despite the objections of producers, geese have to be depinned and this, allegedly, runs the cost of processing up to uncompetitive levels, to $4 a bird last year and probably as high as $6 this year, which helps explain why geese will run well over $2 a pound in supermarkets this Christmas.

To get those pins out, slaughtered birds with the main feathers already removed are dipped in wax and then in cold water. Teams of women pull off the wax and if all goes well, the pinfeathers come out with it. Otherwise, spot-checking USDA inspectors shut the line down. On a good day, Pietrus processes 3,000 geese. A comparable chicken-processing facility can handle 80,000 birds in the same space of time.

These figures do not make goose producers happy, but they and the rest of the anachronistic factors in goose breeding may have something to do with the delicious, nonindustrial taste of geese in the market. At any rate, good geese do appear in our markets in the late fall. Vigorous publicity by the National Goose Council has even caused a slight rise in annual sales. This has recently encouraged modest gains in production. And that means that more of us can join the happy Americans who enjoy a traditional American Christmas dinner. Few, however, will dine on Mr. Bordley's Christmas Pie, as described in the Lloyd Papers at the Maryland Histori-

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cal Society (reprinted in *Maryland's Way: The Hammond-Harwood House Cook Book*):

In Glasse's Book [*Art of Cookery Made Plain and Easy*, by Hannah Glasse, first published in England in 1747, and frequently reissued in America as well as England] is a Yorkshire Christmas Pie which seems to be much like what used to be in my Family: but the Cooke is dead who made them, so that the method she used is lost.

A *fat* Swan, however old, is fine; as is the whole Pie, when it has been frozen and thawed several Times, and is of sound standing. Our Materials were, a Swan, a Turkey or two, a Goose, 2 or 4 Pullets, 2 or 4 ducks, sometimes Beef Steaks, etc. It is fortunate to have a cold Winter for freezing the Pie often, by which the old Swan, the Crust etc. are improved and made tender—the Crust short.

Mr. Bordley's recipe is obviously uncookable as written but may serve as a rough example of how traditional British cuisine was transplanted to America. A more practical old Maryland goose recipe, adapted from *Maryland's Way*, follows.

Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.

The Granger Collection

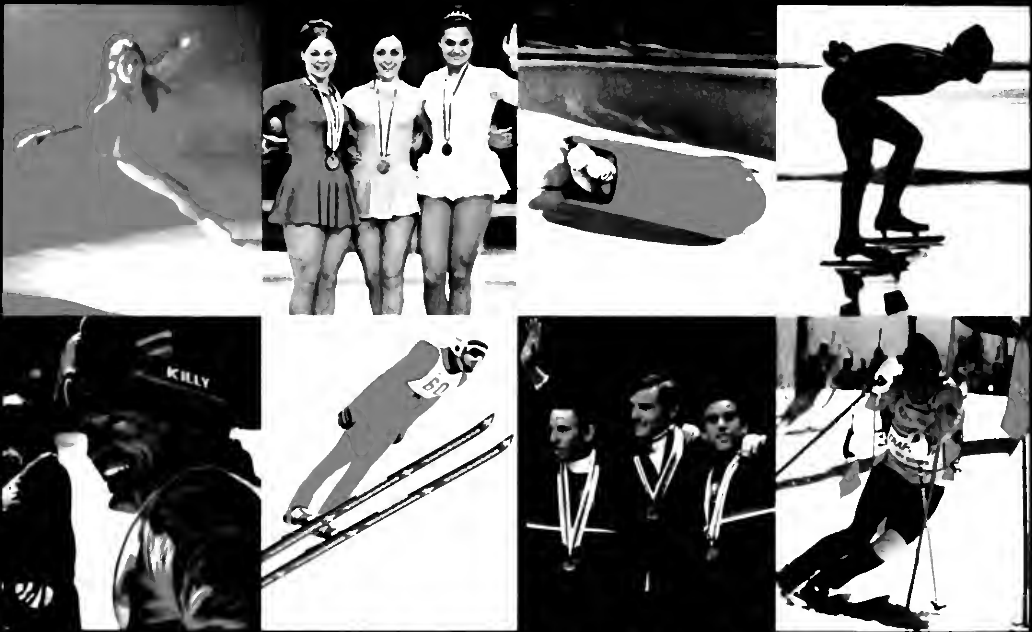
Bob Cratchit's Christmas dinner

Roast Goose with Potato and Sausage Stuffing

1 10-pound goose
Salt
Marjoram
3 tablespoons chopped onion
3 tablespoons butter
4 cups potatoes, parboiled 5 minutes, peeled, and diced
½ pound sausage meat
Pepper
2–3 tablespoons browned butter

1. Clean goose inside and out, removing any patches of fat (which can be rendered and reserved). Rub inside with salt and a little marjoram. Rub outside with salt. Let stand to ripen while preparing stuffing.
2. Sauté onions in butter. Then add potatoes and sausage meat. Season with pepper and very little salt. Mix well and stuff goose lightly.
3. Preheat oven to 375 degrees.
4. Prick goose all over and cook, breast down, on a rack in a covered roasting pan filled with hot water to rack height only.
5. Cook one hour, then turn goose over and prick again. Finish cooking with cover off. Throughout cooking, baste frequently with pan gravy and a little water, skimming off excess fat (which, again, should be reserved for use in cooking). Allow about 20 minutes per pound (3 hours, 20 minutes). Ten minutes before goose is done, baste with browned butter and turn heat up a little to crisp skin. Serve with spiced crab apples or applesauce.

Yield: Six festive portions



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Nothing in the world of competitive sport can match the Olympic challenge. It is a challenge that demands not only the best in human athletic achievement, but a determination that can be summoned up to overcome seemingly impossible obstacles. Yet with all the talent, skill and dreams the Olympic Games focus into crystal clarity for a brief instant, there can be only a few who wear the gold.

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But the Olympic Games are just one way we prove to you we're the best. It's in every Canon product you buy. Proving itself in your studio or on location. It's a quality standard that goes deeper than the name on the pentaprism, the difference between Canon cameras and others that seem to offer equivalent performance. And it's something that just can't be faked.

It's natural that when you think about the Olympics, you think about superlatives. At Canon, we don't use superlatives lightly. We take being "best" very seriously.

And we know you do, too.

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It's better to give than receive.
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